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Comptes rendus du 25e colioque annuel de toxicologie aquatique: 18-21 octobre 1998, Québec, Québec /

Proceedings of the 25th Annual Aquatic Toxicity Workshop: October 18-21, 1998, Quebec City, Quebec

Éditeurs/Editors

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1999

Rapport technique canadien des sciences halieutiques et aquatiques No. 2260

/Canadian Technical Report of Fisheries and Aquatic Sciences No. 2260

Fisheries and Oceans / Pêches et Océans

Canada

Rapport technique canadien des
sciences halieutiques et aquatiques

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Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

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Rapport technique canadien des sciences halieutiques et aquatiques No. 2260 /
Canadian Technical Report of Fisheries and Aquatic Sciences No. 2260

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PRÉFACE

Le 25e colloque annuel de toxicologie aquatique a eu lieu au Château Frontenac, Québec, Québec, entre les 18 et 21 octobre 1998. Le colloque comportait 3 cours de formation, une visite industrielle et scientifique, 3 présentations plénières, 117 exposés, un panel, 78 communications par affichage et 8 kiosques ; 373 personnes ont assisté au colloque.

Le 25e colloque annuel sur la toxicité aquatique a permis de poursuivre les discussions tenues annuellement au Canada sur la toxicologie aquatique et l'écotoxicologie. Ces colloques annuels organisés par un comité national constitué légalement réunissent des représentants des industries, gouvernements et universités. Ces derniers y échangent des idées et des connaissances sur les notions fondamentales de la toxicologie aquatique, mais aussi sur son application pour la surveillance de l'environnement, l'élaboration de lignes directrices et de règlements et la définition de critères pour les sédiments et la qualité de l'eau. Ils passent également en revue les principes de la spécialité, les questions d'actualité et les méthodes adoptées dans le domaine. Les comptes rendus sont publiés avec l'aide du ministère des Pêches et Océans du Canada.

PREFACE

The 25th Annual Aquatic Toxicity Workshop was held at the Château Frontenac, Quebec City, Quebec, October 18 to 21, 1998. The Workshop included 3 short courses, one industrial and scientific tour, 3 plenary presentations, 117 platform papers, one panel, 78 poster papers and 8 exhibitions. Total attendance was 373.

The 25th Annual Aquatic Toxicity Workshop was one of a continuing series of annual workshops in Canada on aquatic and ecotoxicology, covering topics from basic aquatic toxicology to applications in environmental monitoring, setting of regulations and guidelines, and the development of sediment and water quality criteria. These workshops emphasize an informal exchange of ideas and knowledge on the topics among interested persons from industry, governments and universities. They provide an annual focus on the principles, current problems and approaches in aquatic toxicology. These workshops are run by an incorporated National Steering Committee, and the proceedings are published with the support of the Department of Fisheries and Oceans of Canada.

REMARQUES DES ÉDITEURS

Ces comptes rendus renferment les résumés des 117 exposés et 78 affiches présentés au colloque. Une liste des participants est aussi incluse. Les résumés ont été revus sommairement par les éditeurs. On est prié de communiquer directement avec les auteurs pour faire des remarques sur leurs travaux. Toutes les déclarations et opinions paraissant dans le présent rapport sont celles des communicateurs, elles ne sont ni approuvées, ni rejetées par les éditeurs. La mention de marques de commerce ou de produits commercialisés ne constitue ni une approbation, ni une recommandation d'emploi.

EDITORS COMMENTS

This volume contains abstracts of 117 platform and 78 poster papers presented at the workshop. A list of participants is also included. The abstracts were subject to limited review by the editors. Comments on any aspect of individual contributions should be directed to the authors. Any statements or views presented here are totally those of the speakers and are neither condoned or rejected by the editors. Mention of trade names or commercial products does not constitute endorsement of recommendation for use.

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PROGRAMME GÉNÉRAL

GENERAL PROGRAM

Dimanche 18 Octobre — Sunday October 18

08h30 - 12h00	COURS DE FORMATION — SHORT COURSES **1) Toxicity identification evaluation (TIE) : a practical tool for industrial and environmental problem solving.** Formateurs/Instructors : D. Birkholz, A Qureshi and S. Goudey **2) Calculating statistical endpoints :** Formateur/Instructor : M. Zajdlik **3) In situ exposures using caged bivalves** Formateurs/Instructors : M. Salazar and S. Salazar
13h00 -17h00	VISITE — TOUR Visite industrielle et scientifique (Daishowa et laboratoires de toxicité du MEF) Industrial and scientific Tour (Daishowa and MEF toxicity laboratories)
16h00 -18h30	Inscription — Registration (salle Verchères)
Salle / Room	SALON ROSE
18h30 -21h00	Cocktail du CTA — ATW Cocktail

Lundi 19 Octobre — Monday October 19

07h30 - 16h00	Inscription / Registration (salle Verchères)		
Salle / Room	FRONTENAC		
08h30 - 10h00	Introduction Conférences d'ouverture — Keynote addresses		
10h00 - 10h15	PAUSE SANTÉ / BREAK, SALLE VERCHÈRES		
	SESSIONS ORALES — PLATFORM SESSIONS		
Salle / Room	FRONTENAC	CARTIER	LAVAL
10h20 - 12h00	Session A Évaluation de la toxicité I : développement de méthodes *Toxicity Evaluation I : Methods Development*	Session B Perturbateurs endocriniens et immunologiques I *Endocrine and Immunological Disruptors I*	Session C Critères de qualité : nouveaux développements *Quality Criteria : Recent Developments*
12h00	LUNCH, salle de bal		
13h30 -15h40	Session D Évaluation de la toxicité II : sols *Toxicity Evaluation II : Soils*	Session E Perturbateurs endocriniens et immunologiques II *Endocrine and Immunological Disruptors II*	Session F Santé des écosystèmes : fleuves et Grands Lacs *Ecosystems health of large rivers and great lakes*
15h40 - 16h00	PAUSE SANTÉ / BREAK, SALLE VERCHÈRES		
16h00 -18h00	SESSION D'AFFICHES 1 — POSTER SESSION 1		
Salle / Room	PLACE D'ARMES		
16h30 - 18h00	(PO-01 à/to PO-40)		
	BAR		
Salle / Room	MONTCALM		
18h30 - 22h30	Rencontre du Comité permanent des CTA Meeting of the ATW steering Committee		
	SOIRÉE LIBRE — FREE NIGHT		

Mardi 20 Octobre — Tuesday October 20

07h30 - 16h00	Inscription / Registration (Salle Verchères)		
	SESSIONS ORALES — PLATFORM SESSIONS		
Salle / Room	FRONTENAC	CARTIER	LAVAL
08h30 - 10h00	Session G	Session H	Session J
	Évaluation de la toxicité III : métaux, sédiments, effluents *Toxicity Evaluation III : Metals, sediments & effluents*	Rejets miniers et Programme ETIMA *Mining wastes and AETA Program*	Pollution marine *Marine Pollution*
10h00 - 10h20	PAUSE SANTÉ / BREAK, SALLE VERCHÈRES		
10h20 - 12h00	Session G (suite)	Session H (suite)	Session J (suite)
12h00	LUNCH, salle de Bal		
13h30 -15h00	Session K Science et politique réglementaire *Science and Regulatory Policy*	Session L Pâtes et papiers *Pulp & Paper*	Session M Sédiments marins *Marine Sediments*
15h00 - 15h20	PAUSE SANTÉ / BREAK, SALLE VERCHÈRES		
15h20 -16h00	Session K (suite)	Session L (suite)	Session M (suite)
16h00 –18h00	SESSION D'AFFICHES 2 — POSTER SESSION 2		
Salle / Room	PLACE D'ARMES		
	(PO-41-PO-78)		
16h30 - 18h00	BAR		
18h30	BANQUET AND 25TH ANNIVERSARY OF ATW, SALLE DE BAL		

Mercredi 21 Octobre — Wednesday October 21

07h30 - 14 h	Inscription/Registration (salle Verchères)		
	SESSIONS ORALES — PLATFORM SESSIONS		
Salle / Room	FRONTENAC	CARTIER	LAVAL
08h30 - 12h00	Session N	Session O	Session P
	Biodisponibilité et bioaccumulation des métaux *Metal Biovailability and Bioaccumulation*	Évaluation de danger et de risque *Hazard and Risk assessment*	Biomarqueurs I : génotoxicité *Biomarkers I : Genotoxicity*
10h00 - 10h20	PAUSE SANTÉ / BREAK, SALLE VERCHÈRES		
10h20 - 12h00	Session N (suite)	SESSION O (SUITE)	Session P Biomarqueurs II : espèces marines *Biomarkers II : Marine species*
12h00	LUNCH, salle de Bal		
13h30 -15h20	Session Q Évaluation de la toxicité IV : effluents *Toxicity Evaluation IV : Effluents*	Session R Biomarqueurs III : métaux *Biomarkers III : Metals*	Session S Atelier sur les objectifs environnementaux de rejet *Workshop on effluent environmental objectives*
Salle / Room	Frontenac		
15h20 –16h00	Prix étudiants — Student Awards Mot de clôture — Concluding Remarks		

PROGRAMME SCIENTIFIQUE

SCIENTIFIC PROGRAM

Lundi 19 octobre AM Monday October 19

FRONTENAC

08h30 Mot d'ouverture / Opening remarks
Dr Raymond Van Coillie, Université du Québec, Sainte-Foy, Québec

08h45 Reflexions on the state of ecotoxicological research challenges for the next century
Dr Peter Campbell, INRS-EAU, Université du Québec, INRS-EAU, Sainte-Foy, Québec

09h30 Ocean Security
M. John Karau, Environment Canada, Ottawa, Ontario

10H00	PAUSE SANTÉ / BREAK		
SALLE/ROOM	FRONTENAC	CARTIER	LAVAL
Session Prés. / Chair	**Évaluation de la toxicité I : développement de méthodes** **Toxicity Evaluation I : Methods development** **Richard Scroggins**	**Perturbateurs endocriniens et immunologiques I** **Endocrine and Immunological Disruptors I** **Jim Sherry**	**Critères de qualité : nouveaux développements** **Quality Criteria : Recent Developments** **Les Swain**
10H15	INTRODUCTION	INTRODUCTION	INTRODUCTION
10h20	**A1** Using a micro-electrochemical cell for a phytotoxicity screening test **Lagerge, D., J. Chartrand, R. Rouillon , R. Carpentier**	**B1** Why we can not accurately predict the androgen receptor binding properties of environmental chemicals in fish **Wells K., G. Van Der Kraak**	**C1** Overview of SETAC June 1998 Workshop : re-evaluation of the state of science for water quality criteria development **Kent R.A., D.J. Spry**
10h40	**A2** Environment Canada's new test method for measuring inhibition of growth using the macrophyte, *Lemna minor* **Miller J.A., R.P. Scroggins**	**B2** (Anti)estrogenic effects in organic extracts of complex environmental samples **Gagné F., M. Pardos , C. Blaise**	**C2** The role of probalistic analysis in guideline /criteria development **Caux P.Y., C. Gaudet**
11h00	**A3** Contrôle de qualité en toxicologie aquatique: application et pertinence **Bastien, C., R. Cardin, R. Lemire, H. Pelletier**	**B3** Inter-sex in fish exposed to endocrine disruptor substances - lessons to be learned from the medaka model **Metcalfe C.D., T.L. Metcalfe, M.A. Gray, Y. Kiparissis, A.J. Niimi**	**C3** Why not biomarkers for environmental risk assessment? **Hodson P.V.**
11h20	**A4** Comparison of toxicity test results using different dilution waters **Schroeder, J., R. Scroggins, J. Papineau, G. Dixon**	**B4** Steroid concentrations in goldfish exposed to effluent and waste streams from a Canadian bleached sulphite mill **Parrott J. *et al.***	**C4** Use of aquatic invertebrates to evaluate bioavailable metal concentrations in lakes **Hare L., A. Tessier**
11h40	**A5** Mésocosmes : approches théoriques et pratiques **Thybaud É.**	**B5** Sewage sludges and waste water from selected industrial sectors and their potential contents of endocrine disrupting compounds **Hansen P.D. *et al.***	**C5** Cadmium source for benthic invertebrates inferred from an *in situ* experiment: Implication for the AVS model **Tessier A., L. Hare , L. Warren**
12H00	LUNCH		

Lundi le 19 octobre — PM — Monday October 19

SALLE/ROOM	FRONTENAC	CARTIER	LAVAL
	Évaluation de la toxicité II : sols	**Perturbateurs endocriniens et immunologiques II**	**Santé des écosystèmes : fleuves et Grands Lacs**
Session	**Toxicity Evaluation II : Soils**	**Endocrine and immunological disruptors II**	**Ecosystem health of large rivers and great lakes**
Prés./ Chair	**Adrien Pilon**	**Peter Hodson**	**Jacques Cerf**
13H35	INTRODUCTION	INTRODUCTION	INTRODUCTION
13h40	D1 A Tier II approach for the determination and remediation of drilling fluid toxicity to terrestrial organisms Brown M.A., S. Ramamoorthy, A. Morton	E1 Everything I need to know about biomarkers I should have learned in preschool **Munkittrick K.R.**	F1 Qualité des eaux du fleuve Saint-Laurent, 1990 à 1997 **Hébert S.**
14h00	D2 Toxicity assessment of unrefined crude oil fractions **Goudey J.S., J.J. Wilson, A. Chu**	E2 Use of rainbow trout (*Oncorhynchus mykiss*) and brown trout (*Salmo trutta*) to screen Hamilton Harbour water for estrogenic effects **Gamble A.V. *et al.***	F2 L'utilisation de cellules à dialyse et de mousses aquatiques pour le suivi de la qualité des eaux du Richelieu **Berryman D.**
14h20	D3 Characterization of Dinitrotoluenes and some of their reduced metabolites using aquatic-based toxicity tests **Sunahara G.I. *et al.***	E3 Comparison of innate immune parameters from *Oncorhynchus mykiss* caged at various sites in Hamilton Harbour **Karrow N.A. *et al.***	F3 La caractérisation de l'aluminium dans la rivière Saguenay **Roy R.L. *et al.***
14h40	D4 Ecotoxicological effects of TNT (2,4,6-Trinitrotoluene) on soil microbes: a comparison of results from a laboratory spiking experiment and a field sampling of contaminated sites **Ping G., S. D. Siciliano, G. I. Sunahara**	E4 Immunotoxicity biomarkers in fish : development validation and application in feral populations **Zelikoff J.T., M. Anderson, Y.Li, E. Carlson, A. Raymond**	F4 Indice biotique à intégrité piscicole (IBIP) pour évaluer la qualité écologique des écosystèmes lotiques **Micha J.C., J. Didier, P. Kestemont**
15H00	PAUSE SANTÉ / BREAK		
15h20	D5 Biomarqueurs de phytogénotoxicité - intérêt du test *Vicia*-Micronoyau dans différentes études de cas **Férard, J.F., S. Cotelle, J.F. Masfaraud**	E5 Where have our amphibians gone? Suppression of phagocytosis and lymphocyte proliferation following *in vitro* exposure of *Xenopus* leukocytes to heavy metals **Brousseau P. *et al.***	F5 Status of benthic communities in areas of concern in the Great Lakes **Kilgour B.W., T.B. Reynoldson, R.C. Bailey**
15h40	D6 Toxicity evaluation of a bioslurry process treating soils spiked with explosives **Rocheleau S. *et al.***	E6 Immunomodulation by heavy metals tested individually or in mixtures in rainbow trout (*Oncorhynchus mykiss*) exposed *in vivo* **Fournier M. *et al.***	F6 Land use and the decline of freshwater mussel species in lower Great Lakes watersheds **Scott I.M., J.L. Metcalfe-Smith, S.K. Staton**
16h00	**PLACE D'ARMES** **SESSION D'AFFICHAGE 1 — POSTER SESSION 1** **PO- 01 --- PO-40** **CONCURRENT BAR (16H30)**		

Mardi 20 octobre AM Tuesday October 20

Salle/Room	FRONTENAC	CARTIER	LAVAL
Session	**Évaluation de la toxicité III : métaux, sédiments, effluents** **Toxicity Evaluation II : Metals, Sediments, Effluents**	**Mines et Programme ÉTIMA** **Mining and the AETA Program**	**Pollution marine** **Marine Pollution**
Prés./ Chair	**Peter Chapman**	**Diane Campbell**	**Jocelyne Pellerin**
08H35	INTRODUCTION	INTRODUCTION	INTRODUCTION
08h40	G1 Weight loss and abnormal net construction in a net spinning caddisfly (*Hydropsyche*) larva exposed to elevated concentrations of zinc **Balch G., D. Evans, P. Welbourn, R. Prairie**	H1 Synthesis of the aquatic evaluation technology evaluation (AETE) program **Wren C.D., J. Papineau, D. Campbell, L. Trudel**	J1 The Department of Fisheries and Oceans' Toxic Chemicals Program **Vandermeulen H.**
09h00	G2 Effect of soft water and aluminium on cardiac output and swimming performance of rainbow trout **Bézaire-Dussault E., R.C. Playle , R. S. McKinley**	H2 AETE 1997 field evaluation of aquatic monitoring methods at four Canadian mine sites **Farara D.G., P. McKee, D.R. Hart, B. Sander**	J2 Partners in improving Canada's aquatic environment **Pakenham M.**
09h20	G3 Is nickel subsulfide an important environmental contaminant ? **Fåhræus-van Ree G.E., F. Power, J.F. Payne**	H3 Evaluation of sediment extraction procedures and the sediment quality triad at three Canadian mine sites **McKee P., D. Hart, D. Farara**	J3 Recent butyltin contamination in beluga whales (*Delphinapterus leucas*) from the St. Lawrence estuary **Saint-Louis R., S. de Mora, E. Pelletier, I. Mikaelian**
09h40	G4 OxyPAH loading at PAH contaminated sites in southern Ontario **McConkey B.J., X.D. Huang, D.G. Dixon, B.M. Greenberg**	H4 Toxicity identification / reduction evaluations for the canadian mining industry **Novak L.J., R.R. Roy, K.H. Holtze, J. Papineau**	J4 Immunotoxicological study in beluga whales **Fournier M. *et al.***
10H00	PAUSE SANTÉ / BREAK		
	suite		
Prés. / Chair	**Christian Blaise**	**Elizabeth Gardiner**	**Kevin Doe**
10h20	G5 Performance of biological tests in estimating the sublethal toxicity of mining effluents **Scroggins R., J. Schroeder, R. Roy**	H5 Aquatic toxicity associated with diamond mining 1 **Witteman J., D.A. Birkholz, S.E. Goudey, C. Rousseaux, J. Zelikoff**	J5 Toxicity of azamethiphos and cypermethrin, and environmental risk from their use as sea lice control chemicals for Atlantic salmon aquaculture sites **Jackman P.M., K.G. Doe**
10h40	G6 Development and application of bioassays for aquatic environment management in the North East Pacific region **Kusui T.**	H6 Aquatic toxicity associated with diamond mining 6 **Birkholz D.A., J. Witteman, S.E. Goudey, C. Rousseaux, J. Zelikoff**	J6 Dispersion of solutions used to treat sea lice on salmon in net pen enclosures **Ernst W. *et al.***
11h00	G7 Construction d'un indice d'écotoxicité des effluents par régression PLS **Vindimian C.É., J. Garric, P. Flammarion, É. Thybaud, M. Babut**	H7 Considerations for monitoring aquatic effects of mine operations in Honduras/ effects of resource utilization : Mining, forestry and agriculture **Tae M.**	J7 Development of a biochemical assay for assessing toxicity to invertebrate and fish sperm **Hamoutene D., C. Andrews, A. Rahimtula, J.F. Payne**
11h20	G8 Aquatic toxicity of untreated and treated textile mill effluents **Rutherford L.A., W.R. Ernst, C.A. Garron, P. Jackman, K.G. Doe**	H8 Application of the sediment quality Triad for evaluating the impact of a uranium mine effluent on benthic communities in Northern Saskatchewan **Liber K., D. Wang, S. Sobey**	J8 Comparison of sea urchin fertilization test results using natural and synthetic marine water **Jonczyk E., G. Gilron, B. Zajdlik**
11h40	G9 Ammonia toxicity in alkaline mine-mill effluent : The influence of atmospheric carbon dioxide on pH and unionized ammonia **Clark S.J., J.R. Morris, C.E. Hunt, G.D. Watson**	H9 Métaux dans les sédiments : réponses biologiques observées à proximité d'activités minières et métallurgiques **Prairie R.**	J9 Campestrol in caged mussels as a tracer of pulp and paper mill effluents **Salazar M.H., S. M. Salazar**
12H00	LUNCH		

Mardi 20 octobre — AM — Tuesday October 20

Salle/Room	FRONTENAC	CARTIER	LAVAL
Session	**Science et politique réglementaire** **Science and Regulatory Policy**	**Pâtes et papiers** **Pulp and Paper**	**Sédiments marins** **Marine Sediments**
Prés./ Chair	**Robert Prairie**	**Louis Désilets**	**Jean Pluze**
13h35	INTRODUCTION	INTRODUCTION	INTRODUCTION
13h40	**K1**- Les sédiments d'eau douce témoins en Belgique de l'incorporation des métaux lourds : distinction des apports anthropique et détritique **Thomas M., D. Petit, L. Lamberts**	**L1** Effects of bleached kraft mill effluent (BKME) exposure on hepatic lipid peroxydation in a feral white sucker (*Catostomus commersoni*) population **Oakes K.D., G.J. Van Der Kraak**	**M1** Generating a marine toxicity database for ordnance compounds **Nipper M. *et al.***
14h00	**K2** Environmental effect monitoring for the metal mining industry **Hedley K., B. Michelutti**	**L2** Effects of sulphite and bleached kraft pulp and paper mill effluents on yellow perch and johnnie darters **Frank M., M. McMaster, K. Munkittrick, M.C. Savoie, C. Wood**	**M2**- Toxicity identification evaluation (TIE) studies at sites suspected of ordnance contamination **Carr S., M. Nipper, J. Biedenbach, R. Hooten, S. Saepoff, K. Miller**
14h20	**K3** Derivation and application of water quality criteria: Junk science or voodoo cult? **Paine M.**	**L3** The role of pulp bleaching in MFO induction in rainbow trout **Coakley J.D., P.V. Hodson., A.R.P. Van Heiningen, T. Cross**	**M3** Évaluation de la qualité des sédiments à un site de dépôt de matériaux de dragage au moyen d'une approche en triade **St-Laurent D., C. Côté, M. Provencher**
14h40	**K4** Tissue residue guidelines for the protection of wildlife consumers of aquatic life: Dioxin-like compounds **Roe S.L., R.A. Kent, P.-Y. Caux**	**L4** The utility of mesocosms/field bioassays as an alternative to the Canadian environmental effects monitoring (EEM) program adult fish survey **Dubé M.G., J.M. Culp, W.R. Parker, S. Courtenay, J.A. Smith**	**M4** The use and selection of marine toxicity tests for the evaluation of contaminated sediment **Gilron G., E. Jonczyk, R.S. Carr , P. McKee**
15h00	**PAUSE SANTÉ / BREAK**		
15h20	**K5** Canadian soil quality guidelines for petroleum hydrocarbons **Gaudet C. *et al.***	**L5** Environmental effects monitoring at pulp and paper mills discharging to the marine environment **Parker R., M. Hagen, J. Boyd , C. Langlois**	**M5** Sediment contaminant monitoring data from the coastal gulf of Mexico and its usefulness in hazard assessment **Engel D.W., D.W. Evans**
15h40	**K6** Identification et gestion des substances persistantes et bioaccumulables ciblées pour l'élimination virtuelle de l'environnement **Chénier R.**	**L6** Études de suivi des effets sur l'environnement (ESEE) des fabriques de pâtes et papiers du Québec : synthèse des résultats du cycle 1 en eaux douces **Langlois C., D. St-Laurent , N. Dubuc**	**M6** Comparative fate of polycyclic aromatic compounds (PACs): Presence, biodegradation, bioaccumulation and bioelimination **Hellou J. *et al.*.**
16h00	**PLACE D'ARMES** **SESSION D'AFFICHAGE 2 — POSTER SESSION 2** **PO- 41 --- PO-78** **CONCURRENT BAR (16H30)**		

Mercredi 21 octobre AM Wednesday October 21

Salle/Room	FRONTENAC	CARTIER	LAVAL
Session	**Biodisponibilité et bioaccumulation des métaux** **Metal Bioavailability & Bioaccumulation**	**Évaluation de danger et de risque** **Hazard & Risk Assessment**	**Biomarqueurs I : génotoxicité** **Biomarkers I : Genotoxicity**
Prés./ Chair	**Landis Hare**	**Roger Schetagne**	**Chris Metcalfe**
08h35	INTRODUCTION	INTRODUCTION	INTRODUCTION
08h40	**N1** L'utilisation des mousses aquatiques pour le suivi du cadmium en milieu aquatique : influence de différents paramètres sur l'accumulation **Croisetière L., L. Hare, G. Vaillancourt**	**O1** Selenium freshwater quality determinations **Chapman P.M.**	**P1** EROD, DNA adducts and micronuclei as biomarkers of genotoxicity in *Xenopus laevis :* Environmental application **Bekaert C., J. Marty, A. Pfohl-Leszkowicz, L. Gauthier, V. Ferrier**
09h00	**N2** The bioavailable mercury species in aquatic environments : Examples from *in situ* measurements **Cossa D.**	**O2** Évaluation écotoxicologique des sédiments situés à proximité de deux quais à vocation industrielle **Prairie R., Y. Lavergne, C. Côté**	**P2** Assessment of oil sands process water toxicity in wetlands of Northern Alberta using chironomid mentum deformities **Whelly M.P., J.J.H. Ciborowski**
09h20	**N3** Interactions of silver with a unicellular alga: Transport mechanisms through the cell wall and the plasma membrane in relation to chemical speciation **Fortin C., P.G.C. Campbell**	**O3** Développement de méthodes de caractérisation des déchets et des risques écotoxiques liés aux déchets et aux sols contaminés **Bispo A., M. Jauzein**	**P3** Assessment of nuclear DNA damage in the red blood cells of various populations of juvenile chinook salmon (*Oncorhynchus tshawytscha*) in Kitimat Arm **Easton M.**
09h40	**N4** Protective effects of dissolved organic matter against the physiological and toxicological effects of waterborne silver on fish and *Hyalella* **Rose-Janes N., M. Schwartz, R.C. Playle**	**O4** Ecotoxicological risk assessment of a 2,4,6-Trinitrotoluene (TNT) contaminated site **Robidoux P.Y., J. Hawari, S. Thiboutot, G. Ampleman, G.I. Sunahara**	**P4** Tumors and contaminants in lake whitefish (*Coregonus clupeaformis*) from the St. Lawrence River, Quebec, Canada **Mikaelian I., Y. De Lafontaine, C. Menard, J.C. Harshbarger, D. Martineau**
10h00	PAUSE SANTÉ / BREAK		
Prés./ Chair	**suite**	**suite** **Louis Martel**	**Biomarqueurs II: Espèces marines** **Biomarkers II: Marine species** **Peter Hansen**
10h20	**N5** Interactions of humic substances with model biological membranes and phytoplankton surfaces **Vigneault B., A. Percot, M. Lafleur, P.G.C. Campbell**	**O5** Ecological and human health risk assessment of a contaminated harbour facility in Montreal **Côté C. *et al.***	**P5** Recent studies of marine fish and bivalves for biomarker based pollution monitoring in the North Sea and Baltic Sea **Hansen P.D., H. Dizer, V. Bissinger, H. Silva de Assis**
10h40	**N6** Bioaccumulation et devenir du mercure et du plomb dans les rhizomes de scirpes du fleuve Saint-Laurent **Van Coillie R.**	**O6** L'analyse de risques d'accidents technologiques majeurs et l'évaluation environnementale des projets au Québec **Théberge M.C.**	**P6** Études de biomarqueurs des mollusques bivalves (*Mya arenaria*) du fjord du Saguenay, Québec, Canada **Blaise C. *et al.***
11h00	**N7** Comparison of solid phase and overlying water as sources of toxicity to *Hyalella azteca* in lead-spiked sediments **Norwood W., U. Borgmann**	**O7** Évaluation du risque à la santé reliée à la consommation de poissons par des pêcheurs sportifs travaillant à la Baie James **Loranger S., R. Schetagne, M. Plante, L. Houde, Y. Courchesne**	**P7** Effects of marine sediments contaminants on the immune competence of bivalves and plaice **Brousseau P., A. Lacroix, D. Cyr, M. Fournier**
11h20	**N8** Importance of food for the uptake and elimination of cadmium by the aquatic insect *Chaoborus* **Munger C., L. Hare, A. Tessier**	**O8** Using an integrated microexposure event and toxicokinetic model to evaluate impacts of dioxins on angler bodyburdens **Price P.S., R.E.. Keenan, S.J. Pauwels**	**P8** Sources of contaminants in the bleached kraft pulping process and their effects on *Fundulus heteroclitus* (Mummichog) **Dubé M.G., D.L. MacLatchy, K.A. Elliott**
11h40	**N9** Fish mercury bioaccumulation : It is not only what you eat, but how fast you grow ! **Engel D.W., D.W. Evans**	**O9** Trends in the development of ecological risk assessment and management frameworks **Power M., L.S. Mccarty**	
12h00	LUNCH		

Mercredi 21 octobre — PM — Wednesday October 21

Salle/Room	FRONTENAC	CARTIER	LAVAL
Session	**Évaluation de la toxicité IV : effluents** **Toxicity evaluation IV : effluents**	**Biomarqueur III : métaux** **Biomarkers III : metals**	**Atelier sur les objectifs environnementaux de rejets** **Workshop on effluent environmental objectives**
Prés./ Chair	**Normand Bermingham**	**Francine Denizeau**	**Claude Langlois**
13h30	INTRODUCTION	INTRODUCTION	INTRODUCTION
13h40	Q1 Toxicity assessment of effluent from the Cominco metallurgical and fertilizer operations at Trail, B.C. **Duncan W., B. Antcliffe**	R1 Metallothionein as a biomarker for trace metal exposure and effects in *Tubifex tubifex* and *Chironomus riparius* **Gillis P.L., D.G. Dixon, T.B. Reynoldson, L.C. Diener**	S1 Les critères de qualité de l'eau à la base des objectifs environnementaux de rejet (OER) du MEF **Guay I.**
14h00	Q2 Mine effluent-related total dissolved solids (TDS) and water quality criteria **Bailey H., E. Canaria, P.M. Chapman**	R2 Etude de la variabilité spatiale de 5 biomarqueurs mesurés chez la moule zébrée dans le Fleuve Saint-Laurent **DeLafontaine Y., F. Gagné, C. Blaise, G. Costan, P. Gagnon**	S2 Les objectifs environnementaux de rejet (OER) et leur cadre d'application **Richard F.**
14h20	Q3 Results of whole effluent toxicity tests and toxicity identification evaluations conducted on sewage treatment plant effluent discharged into the Hawkesbury-Nepean River system, New South Wales, Australia **Bailey H.C. *et al.***	R3 Metallothionien as a biomarker for metal contamination and toxic effects in freshwater bivalves: Field validation with *Pyganodon grandis* in Abitibi lakes **Couillard Y, *et al.***	S3 Analyse commentée de la méthode de calcul des objectifs environnementaux de rejet (OER) du ministère de l'Environnement et de la Faune du Québec **Rouisse L.**
14h40	Q4 Effluent monitoring results for chronic sublethal toxicity **Abernethy S.**	R4 Impaired physiological response to stress and high levels of metallothionein in Perch (*Perca flavescens*) from lakes contaminated by heavy metals **Laflamme J.S., Y. Couillard, P.G.C. Campbell, A. Hontela**	Atelier sur l'approche de protection du milieu aquatique du MEF
15h00	Q5 Site specific multi-species toxicity testing of sulphate and molybdenum spiked mining effluent and receiving water **Pickard J. , P. Mckee, J. Stroiazzo**	R5 Évaluation de la métallothionéine dans les tissus des poissons comme indicateur d'exposition : études de cas à trois sites miniers canadiens **Trudel L., J. F. Klaverkamp, D. Farara, P. McKee**	**Invités :** **I. Guay, F. Richard, S. Goulet (MEF)** **L. Rouisse (Sanexen services environnementaux inc.)** **L. Désilets (AIFQ)** **R. Van Coillie (UQTR)**
15h30	**FRONTENAC** **Prix étudiants + Mot de fermeture/ Student awards + Concluding remarks** **R. Van Coillie, Université du Québec**		

SESSIONS D'AFFICHAGE

POSTER SESSIONS

LUNDI 19 OCTOBRE — MONDAY OCTOBER 19

AFFICHE — **16h00-18h00** — **POSTER**

ÉVALUATION DE LA TOXICITÉ I : DÉVELOPPEMENT DE MÉTHODES / TOXICITY EVALUATION I : METHOD DEVELOPMENT

PO-01 - **Bailey H.C., E. Canaria, J. Elphick**
Further applications of salmonid fertilization tests

PO-02 - Boivin P., P. Simard, C. Gagnon, R. Letarte
Recherche de nouveaux indicateurs pour l'évaluation de la toxicité : microorganismes et lignées cellulaires

PO-03 - Croisetière L., R. Carpentier
Mise au point d'un bioessai de phytotoxicité sublétale suraiguë sur *S. leopoliensis* : l'apport de l'électrochimie

PO-04 - Fennell M., J. Bruno
Modifications of Environment Canada's early-life-stage (ELS) tests using salmonid fish (the "embryo" and "embryo/alevin" toxicity-test options)

PO-05 - Fennell M., J. Bruno
Development of Environment Canada's 14-day survival-and-growth test for marine sediments using laboratory-cultured spionid polychaetes

PO-06 - Gagné F. *et al.*
Intercalibration study for the evaluation of toxicity with rainbow trout hepatocytes

PERTURBATEURS ENDOCRINIENS ET IMMUNOLOGIQUES / ENDOCRINE AND IMMUNOLOGICAL DISRUPTORS

PO-07 - Benguira S., A.C. Ricard, J.P. Webert, A. Hontela
Adrenotoxic effects of o,p'-ddd, p,p'-ddd and p,p'-ddt in rainbow trout, *Oncorhynchus mykiss*, *in vivo* and *in vitro*

PO-08 - Benson W.H., A.C. Nimrod, W.C. Colley
Interaction of endocrine modulating substances with an alteration of teleost estrogen receptor

PO-09 - Brown S.B.,*et al.*
Effects of 4-nonylphenol on Atlantic Salmon *(Salmo salar)* molts

PO-10 - Fournier M. *et al.*
Comparative effects of pulp mill effluents on macrophage function in 3 species of fish

PO-11 - Leblond V., A. Hontela
Effects of xenobiotics on fish interrenal cells *in vitro* : use of cell suspensions

PO-12 - Tremblay L., G. Van Der Kraak
Development of an *in vivo* assay to characterize the reproductive effects of individual compounds or complex effluents using sexually immature rainbow trout

PO-13 - Massicotte R., D. Flipo, M. Fournier, B. Trottier
L'application de la cytométrie en flux pour l'étude de l'immunotoxicité des fractions soluble et insoluble de poussières de cimenterie

ÉVALUATION DE LA TOXICITÉ II : SOLS / TOXICITY EVALUATION II : SOILS

PO-14 - Brown M.A., S. Ramamoorthy, S. Maki
A tier II approach to determining site specific toxicity of a metal and hydrocarbon contaminated site to terrestrial organisms

PO-15 - Carle N., J. Hatcher, J. Fujikawa, J.S. Goudey
Toxicity assessment of approved drilling mud additives in the oil and gas sector

PO-16 - Carle N., J. Hatcher, J. Fujikawa, J.S. Goudey
Assessment of toxicity based criteria for disposal of drilling waste in oil and gas exploration

PO-17 - Dodard S.G. *et al.*
Ecotoxicological effects of recalcitrant environmental pollutants on two species of soil invertebrates

PO-18 - Stephenson G.L., K.R. Solomon, B.M. Greenberg, R. Scroggins
Toxicity assessment of contaminated site soils using a battery of terrestrial species

ÉVALUATION DU DANGER ET DU RISQUE — HAZARD AND RISK ASSESSMENT

PO-19 - Billiard S.M., P.V. Hodson, N.C. Bols
Relative potency of polycyclic aromatic hydrocarbons (PAH) for inducing CYP1A1 in juvenile trout (*Oncorhynchus mykiss*)

PO-20 - Bombardier M., N. Bermingham
The sed-tox index : a toxicity-directed management tool to assess and rank sediments based on their hazard. I - Concept and application

PO-21 - Caldbick D.S.
Approaches for estimating the ecological risk of a predominantly naturally-occuring substance : carbon disulfide

PO-22 - Coté C. *et al.*
The use of a weight-of-evidence approach in an ecotoxicological risk assessment of a contaminated harbour facility in Montreal

PO-23 - Eggleton M.
L'évaluation des sels de voirie dans le cadre de la loi canadienne sur la protection de l'environnement

PO-24 - Gold J.R., S.M. Ruby, P.D. Anderson, P. Brousseau
Integration of a human health and ecological risk assessment method (multiple toxicity study of Lake Aylmer area wells)

PO-25 - Loranger S., L. Houde, R. Goudreau, Y Courchesne, B. Langlet
Évaluation du risque écologique que présente la cour d'entreposage de poteaux située à Rimouski

PO-26 - Hanson M.L.
A probabilistic environmental risk assessment of trichloroacetic acid TCA in Canadian tap water

PO-27 - Loranger S., L. Houde, R. Schetagne
Fish intake and methylmercury exposure of recreational and native freshwater anglers in the upper Saint-Maurice region (Quebec - Canada)

PO-28 - Taylor K.W.
Use of models in the environmental assessments of priority substances under the Canadian Environmental Protection Act (CEPA)

PO-29 - Cash K.J., F. Malcolm Conly, T. Bollinger
Avian botulism in prairie Canada

PO-30 - Martel L., R. Chassé, A.M. Lafortune, S. Bisson, C. Thellen
Procédure d'évaluation du risque écotoxicologique pour la réhabilitation des terrains contaminés

BIOMARQUEURS — BIOMARKERS

PO-31 - Brousseau P., Y. Morin, J. Pellerin, D. Cyr, M. Fournier
Comparaison des effets du mercure et du cadmium sur la capacité phagocytaire des hémocytes de myes (*Mya arenaria*) suite à des expositions *in vitro* et *in vivo*

PO-32 - Gauthier-Clerc S., J. Pellerin, C. Blaise
Étude diagnostique de la condition physiologique et du potentiel reproducteur de *Mya arenaria* (mollusque bivalve endobenthique) exposé à la contamination du fjord du Saguenay

PO-33 - Couillard C.M., M. Lebeuf, B. Légaré
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PO-34 - Dionne H., C.M. Couillard, J.P. Chanut
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PO-35 - Doherty M.S.E., L.A. Hudson, J.J.H. Cibobrowski, D.W. Schloesser
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PO-42 - Coté C., D. Milani, L. Trudel
Évaluation de trois essais de toxicité des sédiments à des sites miniers canadiens

PO-43 - George T.K., K. Liber, K.R. Solomon, P.K. Sibley
Toxicity of binary and tertiary organophosphate insecticide mixtures to zooplankton in freshwater microcosms

PO-44 - Hanson M.K., P.K. Sibley, K.R. Solomon, D.C. M. Muir, S.A. Mabury
Growth and health of *Myriophyllium spicatum* and *M. sibiricum* exposed to trichloroacetic acid in aquatic microcosms

PO-45 - Irving E.C., D.J. Baird, J.M. Culp
Ecological responses of a mayfly *Baetis tricaudatus* to cadmium bound to food surfaces

PO-46 - Marwood C.A., K.R. Solomon, R.E. Smith, B.M. Greenberg
Inhibition of photosynthesis in natural assemblages of Lake Erie phytoplankton exposed to polycyclic aromatic hydrocarbons in sunlight

PO-47 - Mayer T. *et al.*
Toxicity of highway runoff in southern Ontario

PO-48 - Milani D., T. B. Reynoldson, J. Kolasa
The relative sensitivity of four benthic invertebrates to cadmium, copper and nickel in spiked sediments and contaminated field sediments

PO-49 - Peters L.E. *et al.*
Analysis of «wet-landscape» surface water fractions using the Medaka embryo-toxicity bioassay

PO-50 - Pyle G.G., S.M. Swanson
Nickel and molybdenum toxicity to freshwater fish

PO-51 - Yang R., J. Pickard, B. Duncan
Acute and sublethal toxicity of thallium to aquatic organisms

PO-52 - Salazar S.M., M.H. Salazar
Reducing uncertainty in risk assessments by measuring effects under realistic exposure conditions : a comparison of laboratory and field approaches

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Evaluation of chemical, biochemical and tissue methods for monitoring effects of effluents from metal mines on fish

PO-54 - Paine M., I. Watson, L. Trudel
Evaluation of fish population and community surveys for monitoring environmental effects of metal mines

PO-55 - Paine M.
Applying and improving before-after-control-impact (BACI) designs in environmental effects monitoring (EEM) programs

PO-56 - Saint-Cyr L., A. Cattaneo, R. Chassé, C.G.J. Fraikin
Macrophytes, phytoplankton and periphyton as biomonitors to assess the impacts of mine effluents on the aquatic environment

PO-57 - Stewart A.R., D.F. Malley, J. Papineau
Technical evaluation of molluscs as a biomonitoring tool for the Canadian mining industry

PO-58 - Goudey S.E., D.A. Birkholz, J. Witteman, C. Rousseaux, J. Zelikoff
Aquatic toxicity associated with diamond mining 2

PO-59 - Birkhloz D.A., J. Witteman, S.E. Goudey, C. Rousseaux, J. Zelikoff
Aquatic toxicity associated with diamond mining 3

PO-60 - Rousseaux C., D.A. Birkholz, J. Witteman, S.E. Goudey, J. Zelikoff
Aquatic toxicity associated with diamond mining 4

PO-61 - Zelikoff J., D.A. Birkholz, C. Rousseaux, J. Witteman, S.E. Goudey
Aquatic toxicity associated with diamond mining 5

POLLUTION MARINE — MARINE POLLUTION

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PO-63 - Lebeuf M., K.E. Bernt, M. Hammill, L. Measures, M. Noël, S. Trottier
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PO-64 - Lee K. *et al.*
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PO-77 - Trudeau F., A.D. Gendron, F. Maisonneuve, C.A. Bishop
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PO-78 - Luross J., D. Sergeant, M. Alaee, M. Whittle, K. Solomon
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RÉSUMÉS DES COMMUNICATIONS

ABSTRACTS

A1

LABERGE[1] D., J. CHARTRAND[1], R. ROUILLON[2] , R. CARPENTIER[1]

USING A MICRO-ELECTROCHEMICAL CELL FOR A PHYTOTOXICITY SCREENING TEST

The photosynthetic process has been well kept through evolution and is largely similar from cyanobacteria to vascular plants. Thus, a toxic interaction at the photosynthetic level is potentially harmful for all the plant species. Several pollutants found in water inhibit the photosynthetic electron transport chain. Among these pollutants, there are herbicides from agricultural lands runoff. The photosynthetic process as a target site for herbicides holds an important place in the agricultural market. A micro-electrochemical cell that uses photosynthetic membranes to generate photocurrent has been developed. The toxic effect of an inhibitor is observed by a decrease in the photocurrent. In this study, photosynthetic membranes were isolated from spinach leaves. To improve the stability of their biological functions, the membranes were immobilized in an albumin-glutaraldehyde crosslinked matrix. The developmental work of this phytotoxicity test was done by using the herbicide atrazine as reference toxicant. Results on reproducibility were in the range generally accepted for standardized bioassays. The phytotoxicity of herbicides from various chemical classes including photosynthetic and non-photosynthetic inhibitors was evaluated. Their responses were compared with an algal growth inhibition test as well as water quality guidelines. There is a need for low-cost techniques enabling rapid detection of toxic effects of effluents or chemical samples. The approach presented here is rapid (exposure time to toxicant of 20 min), easy-to-use, and low-cost. This test may provide a useful screening tool for preliminary phytotoxicity detection, prior to more expensive and extensive testing.

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A2

MILLER[1] J.A., R.P. SCROGGINS[2]

ENVIRONMENT CANADA'S NEW TEST METHOD FOR MEASURING INHIBITION OF GROWTH USING THE MACROPHYTE, *LEMNA MINOR*

The latest method to be standardized as part of Environment Canada's biological test method series is a phytotoxicity test which measures growth inhibition of the common duckweed, *Lemna minor*. The duckweed test which is suitable for testing chemicals, surface waters and wastewater, has been shown to be simple, fast, sensitive and cost effective.

The method incorporates recent research conducted at the Saskatchewan Research Council (SRC) which, in part, focused on improving the proposed American Public Health Association (APHA) *Lemna minor* growth inhibition test procedure. The SRC-modified *Lemna* procedure proved to be a very effective monitoring tool for assessing the potential effect of metal mining liquid effluents when evaluated against other standard toxicity test procedures under the industry/government Aquatic Environmental Technologies Evaluation (AETE) program. Currently, the *Lemna minor* procedure is a strong candidate for consideration as a monitoring technique under the Environmental Effects Monitoring (EEM) component of the amended Metal Mining Liquid Effluent Regulations. As well, recent *Lemna* test guideline standardization efforts of the OECD have assisted Environment Canada in choosing specific aspects of the test procedure, required in method standardization.

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[2] Environment Canada, Ottawa, ON

A3

BASTIEN[1] C., R. CARDIN[1], R. LEMIRE[1], H. PELLETIER[1]

CONTRÔLE DE QUALITÉ EN TOXICOLOGIE AQUATIQUE : APPLICATION ET PERTINENCE

Certains facteurs critiques en toxicologie aquatique tels la qualité de l'eau de dilution, les organismes vivants et le niveau de standardisation des méthodes seront discutés ainsi que la valeur intrinsèque et la pertinence des éléments de contrôle de la qualité tels les groupes témoins, les seuils d'effet, le choix des toxiques de référence et les diagrammes de contrôle.

L'usage des toxiques de référence au cours des dernières années démontre que les coefficients de variation diffèrent beaucoup d'une substance à l'autre et que certains d'entre eux ne permettent pas de déterminer la précision obtenue avec des échantillons réels. Une approche avec effluent reconstitué (matériaux de référence) apparaît souhaitable. De même, la validation des méthodes pour les tests sous-létaux devrait inclure une meilleur connaissance de la variabilité des contrôles en condition de laboratoire ainsi qu'une détermination des seuils d'effet analytique.

Au cours des années 1993 à 1998, dix études interlaboratoires ont été réalisées impliquant les laboratoires de toxicologie du Québec pour les tests de létalité avec la truite arc-en-ciel et la daphnie. Les résultats obtenus démontrent une tendance à la diminution de la variabilité dans le temps. Le CV global des études récentes se situe entre 18 et 23 % alors que le CV global des premières études se situait entre 35 et 45 %. De même, le taux d'échec pour des combinaisons échantillon/paramètre a connu une diminution dans le temps. Des CV aussi faibles que 8 et 9 % ont été obtenus pour des échantillons individuels autant avec la truite arc-en-ciel que la daphnie. La comparaison des données de variabilité avec d'autres domaines d'analyse démontre que la variabilité en toxicologie est similaire à celle en chimie organique pour les matrices d'effluent.

Il apparaît clair que la stabilité de l'expertise en place et des organisations en général, l'implantation rigoureuse des procédures ACQ et une meilleure uniformisation et validation des méthodes soient des facteurs déterminants pour l'amélioration et le maintien de la qualité.

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A4

SCHROEDER[1] J., R. SCROGGINS[2], J. PAPINEAU[3], G. DIXON[4]

COMPARISON OF TOXICITY TEST RESULTS USING DIFFERENT DILUTION WATERS

Laboratory tests using upstream or reference site waters for dilution and controls can be applied in environmental effects monitoring programs or in the development of site specific water quality objectives. Although site water represents the physical/chemical characteristics of the receiving environment, the toxicity of a particular substance may not be better estimated than in a test using laboratory dilution water when tests are conducted under standard laboratory conditions using laboratory-reared organisms. The effects of dilution/control water selection on results of sublethal toxicity tests, using fathead minnows, *Ceriodaphnia dubia* and algae, were assessed by BEAK in partnership with CANMET and the University of Waterloo. Parallel tests of effluents from several mining sites were carried out using three dilution waters: upstream site water, BEAK laboratory water, and BEAK laboratory water adjusted to the hardness of the site water. Each test was conducted using organisms pre-acclimated to the conditions of each dilution water. Several tests were performed using samples from each site in order to assess the variability in toxicity test results over time. Generally, most tests produced similar results and hardness adjustment of laboratory water reduced the variability between site water and laboratory water test results. Practical considerations regarding the storage and use of site water in the laboratory were also investigated and will be discussed along with the comparison studies.

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[4] University of Waterloo, Waterloo, ON

A5

THYBAUD[1] É.

MÉSOCOSMES : APPROCHES THÉORIQUES ET PRATIQUES

L'évaluation de l'écotoxicité des substances chimiques est classiquement réalisée à l'aide de bioessais de laboratoire. Ceux-ci, de par la simplification et le contrôle des conditions environnementales permettent la détermination de la toxicité potentielle de ces substances vis-à-vis des différents constituants des écosystèmes. Cependant, aussi sophistiquées soient elles, ces méthodes représentent toujours une simplification extrême des conditions naturelles rendant toute extrapolation des données obtenues vers le milieu naturel aléatoires. Dans le but d'améliorer les conditions d'évaluation de l'écotoxicité des substances chimiques, Odum (1983) introduisit dès le début des années 80 un nouveau système expérimental, les mésocosmes. Ceux-ci correspondent à des systèmes expérimentaux de taille moyenne, placés en conditions environnementales naturelles et simulant un écosystème naturel.

Ils possèdent de ce fait, un degré d'organisation supérieur à celui des systèmes de laboratoire tout en permettant une simplification des communautés et un contrôle satisfaisant des conditions de contamination. Ils représentent donc un pont entre l'environnement contrôlé du laboratoire et celui incontrôlé du milieu naturel (Kosinski, 1989).

L'utilisation de tels systèmes expérimentaux à des fins réglementaires nécessite de disposer :

- de protocoles standardisés en particulier en ce qui concerne la nature du substrat, les types de communautés, la dynamique de l'eau, les durées de stabulation et de contamination et le type d'approche expérimentale envisagée,
- de critères de validité faisant l'objet d'un large accord,
- et d'informations concernant la pertinence de telles études dans le cadre de l'évaluation des propriétés écotoxicologiques des substances chimiques.

[1] Institut national de l'Environnement industriel et des risques - Verneuil-en-Halatte, France

B1

WELLS[1] K., G. VAN DER KRAAK[1]

WHY WE CAN NOT ACCURATELY PREDICT THE ANDROGEN RECEPTOR BINDING PROPERTIES OF ENVIRONMENTAL CHEMICALS IN FISH

There is growing concern that environmental chemicals may adversely affect growth, reproduction and survival of an organism by altering its endocrine physiology. Frequently, endocrine disrupting chemicals are identified by their ability to bind to hormone receptors and disrupt a hormonal response. However, the fundamental question of whether it is possible to make cross-species extrapolations of receptor binding activities of endocrine disrupting chemicals is unknown. In this study, we tested chemicals that have been demonstrated to bind to androgen receptors (AR) in rats, to see if they bind to AR's in fish. In addition, we tested whether these chemicals bind with different affinities to AR's in different target tissues within fish. High affinity, low capacity cytosolic AR's were isolated from the brains, testes and ovaries of rainbow trout and goldfish. Compounds previously shown to bind to the mammalian AR including 17β-estradiol, flutamide, cyproterone acetate and the pesticides p,p'DDE and vinclozolin, did not compete for binding to the AR in the brains of rainbow trout. However, 17β-estradiol and cyproterone acetate did compete for binding to the AR in the testes and ovaries of goldfish. These results not only demonstrate marked differences between mammalian and fish AR's, they also indicate differences between AR's in different target tissues within fish. This question the applicability of making cross-class as well as cross-tissue comparisons when evaluating suspected endocrine disrupting chemicals.

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B2

GAGNÉ[1] F., M. PARDOS[1], C. BLAISE[1]

(ANTI)ESTROGENIC EFFECTS IN ORGANIC EXTRACTS OF COMPLEX ENVIRONMENTAL SAMPLES

Environmental chemicals can perturb the estrogenic response and other endocrine functions in organisms. Indeed, industrial and municipal effluents are recognized to release (anti)estrogenic compounds in the aquatic environment. The objectives of this study were to study the estrogenic properties of different organic (dichloromethane) extracts of environmental samples using the vitellogenin (Vg) assay in trout hepatocytes. In addition, organic extracts were fractionated by normal phase (SiO_2) chromatography to verify the hypothesis whether less polar chemicals are anti-estrogenic and the more polar chemicals are estrogenic. Therefore, trout hepatocytes were exposed for 48 h at 15°C to environmental extracts such as sediments, snow, industrial and municipal (un)fractionated extracts. After the exposure period, cell viability, cytochrome P4501A1, Vg mRNA levels and secreted Vg were measured. The results showed that most organic extracts of sediments, industrial effluents and municipal suspended matter where estrogenic. The following estrogenic ranking was obtained: suspended matter of municipal waste >> sediments > industrial effluents > snow. Unfractionated extracts, that induced cytochrome P4501A1 activity, showed either absence or antiestrogenic effects. Moreover, when the extracts were resolved into non-polar and polar fractions, cytochrome P4501A1 inducing potential and the antiestrogenic effects were associated with the non-polar fraction while estrogenicity was observed in the polar fraction most of times. In some cases, when the extracts contained high levels of suspended matter, a spill over of the cytochrome P450 1A1 inducers was observed in the polar fraction. The results suggest that environmental mixtures are likely to contain both (anti)estrogens that are linked with the degree of contamination. Antagonist effects of environmental organic mixtures seem to be, in part at least, Ah-receptor mediated. Normal phase chromatography appears to separate non-polar cytochrome P4501A1 inducing substances from more polar chemicals where most of the estrogenic effects were observed. Fractionation of environmental organic extracts should be considered for screening for estrogenic potential.

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B3

METCALFE[1] C.D., T.L. METCALFE[1], M.A. GRAY[1], Y. KIPARISSIS[1], A.J. NIIMI[1]

INTER-SEX IN FISH EXPOSED TO ENDOCRINE DISRUPTOR SUBSTANCES - LESSONS TO BE LEARNED FROM THE MEDAKA MODEL

Recent observations of inter-sex characteristics in fish downstream of sewage treatment plants (STPs) have led to speculation that altered gonadal development in fish may be a biomarker for exposure to estrogenic compounds in effluents. However, before this cause-and-affect linkage can be established, studies are needed to determine the factors that influence alterations to gonadal development in teleosts. Our studies with Japanese medaka, *Oryzias latipes*, a differentiated gonochorist teleost species have shown that exposure of fish to estrogenic chemicals, beginning at the period of gonadal differentiation is optimal for the development of an inter-sex condition of the testis called "testis-ova". However, testis-ova can also be induced when adult medaka are exposed to high concentrations of estrogens; indicating bipotentiality of germ cells in the mature gonad.

[1] Environmental and Resource Studies Program, Trent University, Peterborough, ON

B4

J. PARROTT[1], J. JARDINE[1], B. BLUNT[1], L. MCCARTHY[1], M. MCMASTER[1], K. MUNKITTRICK[1], C. WOOD[2]

STEROID CONCENTRATIONS IN GOLDFISH EXPOSED TO EFFLUENT AND WASTE STREAMS FROM A CANADIAN BLEACHED SULPHITE MILL

During the cycle 1 environmental effects monitoring (EEM) studies, wild fish collected downstream of several Noranda Forest Canadian pulp mills indicated reduced gonad size or fecundity. A two-year collaborative study between Noranda Forest Inc. and the National Water Research Institute of Environment Canada was begun to investigate the reproductive responses. The purpose of the study was to assess final effluents from Noranda Forest Canadian mills for their ability to affect goldfish circulating steroids (testosterone, 11-ketotestosterone) or production of steroids *in vitro* by testes from exposed fish. Along with final effluent, individual waste streams from the mill processes were tested to investigate the potential source(s) of steroid-disrupting compounds from within the mill. The study also provided a chance to study effluent potencies over time as mill processes were changed and upgraded. Goldfish exposed for 16-21 days to final effluent (100 %) from a bleached sulphite mill (BSM) showed reduced testosterone and 11-ketotestosterone production by testes. Testes of goldfish exposed to undiluted final effluent had steroid production one-tenth that of controls. Fish exposed to individual waste streams (2-40 %) had steroid production similar to control fish. It was difficult to assess the waste streams, as fish-exposure concentrations were inconsistent among waste streams due to differences in the acute toxicity of streams. Final effluent from the same mill collected one year later, after numerous mill upgrades (such as changes in chip handling, digester operation and better control of spills), showed an improvement: Goldfish exposed to 100 % effluent showed less decreases in steroid levels. The study demonstrates the use of the goldfish steroid bioassay for detecting changes in effluent quality. The environmental consequences resulting from the improvement in BSM final effluent quality will be tested during the cycle 2 EEM.

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[2] Noranda Technology Centre, Pointe Claire, QC

B5

HANSEN[1] P.D., H. DIZER[1], B. HOCK[2], A. MARX[2], J. SHERRY[3] M. MCMASTER[3], C. BLAISE[4], D. WELTIN[5] , B. BILITEWSKI[5]

SEWAGE SLUDGES AND WASTE WATER FROM SELECTED INDUSTRIAL SECTORS AND THEIR POTENTIAL CONTENTS OF ENDOCRINE DISRUPTING COMPOUNDS

In the extensive waterways in Berlin, Germany, 70% of the fish population is female. The presence of vitellogenin in male fish was choosen as an indicator of exposure to estrogenic compounds. The determination of vitellogenin is accomplished by means of a competitive enzymatic immunoassay (EIA) using monoclonal antibodies. The fish were exposed on site to a mixture of definite amounts of effluent and surface water in the exposure tanks of a flow through system for more than 6 months. The dilution steps (10%, 20% 30% and 40% effluent) are relevant concerning to the effluent loading of the Berlin waterways during the seasons of the year.

There was already a remarkable increase of the vitellogenin in the serum of the fish exposed to > 20% effluent. In cause effect studies with "indicator tests" the endocrine effects of selected single contaminants of the effluents were investigated as well as the effects concerning sex ratio in the F2-generation. There is a safety factor of more than 100 between the nonyphenol concentrations in the effluents and the endocrine effects. The safety factor concerning bisphenol A is approximately 3,000. But there is no safety factor concerning the effects concentrations of the hormones and their concentrations in the effluents and water ways.

Sewage sludge from sewage plants from the City of Meissen (105,000 population equivalents) and a medium sized sewage plant in Lisboa and industries were investigated. Preliminary results of endocrine substances in sewage sludge and treated soils in agricultural areas will be presented .

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[2] Munich University of Technology, Department of Botany, Germany
[3] National Water Research Institute, Burlington, ON
[4] Centre Saint-Laurent, Montréal, QC
[5] Dresden University of Technology, Institute of Waste Management and Contaminated Sites

C1

KENT[1] R.A., D.J. SPRY[2]

OVERVIEW OF SETAC JUNE 1998 WORKSHOP : RE-EVALUATION OF THE STATE OF SCIENCE FOR WATER QUALITY CRITERIA DEVELOPMENT

Over fifty scientists participated in this year's Pellston workshop to evaluate the science underlying current water quality criteria development. Breakout groups discussed problem formulation, exposure assessment, effects assessment and risk assessment as applied to current approaches in the US, Canada, New Zealand and the Netherlands. A major premise was that better knowledge of chemical classes, bioavailability, appropriate receptors and endpoints could reduce the margin of safety while still providing ecological protection and making the best use of the resource. These aspects were evaluated by the exposure and effects groups and will be discussed in the presentation. The problem formulation group recommended three types of criteria. The first would use appropriate «intended level of protection» and «margin of safety» (policy decisions) but make the criteria as site-specific as possible using generic translators or modelling, *e.g.*, the USEPA dissolved metals approach. The second type of criteria would build on the first but use data actually gathered at the site (*e.g.*, bioassay, water effect ratios, bioaccumulation data). The third type would be used where the first two were inappropriate, and would follow the US ecological risk assessment paradigm. The conclusions and recommendations of the workshop will be discussed in relation to current guideline development in Canada and opportunities for the future.

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[2] Standards Development Branch, Ontario Ministry of the Environment, Toronto, ON

C2

CAUX[1] P.Y., C. GAUDET[1]

THE ROLE OF PROBALISTIC ANALYSIS IN GUIDELINE/CRITERIA DEVELOPMENT

Probabilistic analysis is defined as the methods and approaches used in determining the probability of an event occuring with its related uncertainties. In ecotoxicology or in environmental risk assessments, probabilistic analysis is ultimately associated with an adverse effect. Often, deterministic models with detailed parameterized chemical and physical and/or toxicological processes are described. Probabilities are then depicted through probability distribution functions reflecting the input parameters of the system under consideration. This has accounted for the propagation of uncertainty around the input distributions of each of the parameters in the system. At present, the system under consideration is the development of environmental quality guidelines or criteria. Sediment and water quality guideline derivation procedures will be discussed in light of obtaining input parameter probability distributions and their associated uncertainties. A method for quantifying the use of safety factors will also be given. Furthermore we will compare the results of probability techniques for guideline derivation and compare and discuss implications for current deterministic approaches.

[1] Guidelines and Standards Division, Environment Canada, Hull, QC

C3

HODSON[1] P.V.

WHY NOT BIOMARKERS FOR ENVIRONMENTAL RISK ASSESSMENT?

The application of clinical tests to manage human health has always appealed to environmental managers. They see potential benefits of applying biochemical indicators, or biomarkers, to assessing the environmental risks of chemical contamination. In theory, biomarkers of fish and wildlife should be an efficient way to describe the spatial extent of chemical contamination. They may also provide early warning of toxicity, estimates of bioavailability, screening tests for new chemical registration, and inexpensive data for water quality criteria. However, there are few instances where biomarkers have been used routinely. A *Round Table on Biomarkers in Ecosystem and Human Health Assessment* at the 1993 Aquatic Toxicity Workshop in Quebec City, provided some of the reasons why. The most important was a failure to link biomarkers to relevant effects on ecosystems. Regulators, and those being regulated, hesitate to base expensive decisions on responses that may not predict effects. The situation is complicated by differences in sensitivity among species and among life stages of each species, multiple mechanisms of toxicity, and the unknown effects of mixtures. One key to successful application of biomarkers is knowledge of the mode of toxicity. This paper reviews recent research on mixed function oxygenase (MFO) enzyme induction in fish. It shows how induction is linked to several mechanisms of toxicity, how it dictates which fish species and life stage will be most affected, and why it is one of the most promising of potential biomarkers.

[1] School of Environmental Studies, Queen's University, Kingston, ON

C4

HARE[1] L., A. TESSIER[1]

USE OF AQUATIC INVERTEBRATES TO EVALUATE BIOAVAILABLE METAL CONCENTRATIONS IN LAKES

Total metal concentrations in water or sediment generally provide little information on metal concentrations available to living organisms. Measurements of metal concentrations in aquatic animals can provide a less ambiguous means of estimating bioavailable metal concentrations in aquatic ecosystems. Using animals as biomonitors requires the development of appropriate models, the performance of which is likely to be enhanced if these models have a solid chemical and biological base. We tested such a model on the phantom midge *Chaoborus* and the alderfly *Sialis*, two common insects in lakes. Both of these taxa appear to be tolerant of high metal concentrations and low pH, which are valuable attributes for freshwater biomonitors. Our results suggest that these insects could be used to estimate free cadmium ion concentrations in lakes. However, the concentrations of copper and zinc in these animals vary little across a wide range of environmental metal concentrations, suggesting that other taxa will be required for these metals. We suggest that a variety of biomonitor taxa be developed for use in various types of environments (*e.g.*, lakes, rivers, estuaries). Because biomonitors can be used to estimate free metal ions concentrations, their metal concentrations could also serve to indicate the potential for toxic impacts on sensitive species.

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C5

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CADMIUM SOURCE FOR BENTHIC INVERTEBRATES INFERRED FROM AN *IN SITU* EXPERIMENT: IMPLICATION FOR THE AVS MODEL

Metal contaminated sediments are common in lakes downwind from metal smelters, *e.g.* in Rouyn-Noranda. Do animals living in these contaminated sediments accumulate metals from the sediment compartment itself or from the water overlying the sediments? The answer to this question is important for designing regulations to protect aquatic life. We conducted an *in situ* experiment to determine the relative importance of Cd in the sedimentary compartment versus Cd in the overlying water compartment for Cd accumulation by benthic animals. Sediments of a low-Cd Shield lake were artificially contaminated with various amounts of Cd and placed, at a littoral site, in open plastic containers in the lake bottom for 11 months. A gradient in sedimentary (and interstitial water) Cd concentrations was thus created *in situ*, while Cd concentrations in the overlying water remained low since the lake acted as an infinite reservoir for any Cd diffusing out of the containers. At the end of this period, measurements were made of Cd accumulated by benthic animals (12 taxa), as well as of various chemical variables in the porewaters, overlying water and sediments. Despite the large Cd contamination levels reached in the experiment, the population densities of most of the resident taxa appear to have been unaffected by the presence of Cd. We used the results obtained for the experimental containers to predict the compartment from which animals on sediments in the environs took up their Cd. For almost all the taxa studied, individuals living outside the experimental containers took up their cadmium mainly from the overlying water compartment. These results suggest that models to predict metal uptake or toxicity that rely on sedimentary metal concentrations (*e.g.*, the AVS model) may have to be reconsidered.

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D1

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A TIER II APPROACH FOR THE DETERMINATION AND REMEDIATION OF DRILLING FLUID TOXICITY TO TERRESTRIAL ORGANISMS

Some drilling fluids and fraccing liquids have been reported to be toxic to aquatic species (LC50 at 96 hours for Rainbow trout was 2.2%) and the Microtox™ bacteria (IC 50 value in 15 min. was 0.05%). However, their effect on terrestrial organisms and the environmental fate of these fluids is generally unknown. We examined the toxicological effect of a generic 'fraccing' fluid on leaf lettuce (*Latuca sativa capitata*.), radish (*Rhaphanus sativus*) and the earthworm (E. *foetida*). We found the toxic effects were generally less noticeable to both plant species, and virtually non - existant to the worm species as compared to the Microtox™ test. Chemical analyses (via GC/MS and ICP) were performed in an attempt to reveal and identify the presence of potential toxic compounds. The fluid was then subjected to oxidative remediation, bio-remediation and oxidation and biological remediation combined. Because the Microtox™ assay was the most sensitive to the toxicants in the fluid, this test was used to track the decline in toxicity over time. Degradation of this fluid also showed a decrease in the contributing toxicants. The major components in the fluid had a hydrocarbon base in the C14C20 range that could be remediated to a relative non-toxic state.

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D2

GOUDEY[1] J.S., J.J. WILSON[1], A. CHU[2]

TOXICITY ASSESSMENT OF UNREFINED CRUDE OIL FRACTIONS

Petroleum hydrocarbon contamination (PHC) of soils is a serious problem of economic and environmental concern. Information on the toxicity, fate and transport, potential ecological and human health impacts is lacking because there are no consistent approaches to assessing and managing these kinds of complex mixtures. Federal and Provincial regulatory agencies have recognized and are responding to these deficiencies.

There are a number of critical information gaps. The need addressed here is the toxicity of crude oil fractions to selected aquatic and terrestrial species. Paraffinic, asphaltic, and naphthenic crudes were fractionated following standard procedures. The fractions were analyzed by flame ionization gas chromatography for a semi-quantitative assessment of how the fractionation affects the distribution within the C8 to C60 range (typical analysis done for total extractable hydrocarbons). An artificial and field soil were then spiked with the fractions and whole crudes. The results from standard worm and seed tests on the spiked soils and microbial, plant, and invertebrate tests on soil and extracts of the crude fractions are presented here.

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D3

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CHARACTERIZATION OF DINITROTOLUENES AND SOME OF THEIR REDUCED METABOLITES USING AQUATIC-BASED TOXICITY TESTS

Nitro-aromatic compounds, their synthetic by-products and microbial metabolites are present at munitions sites worldwide. The toxicity of many of these chemicals remains poorly characterized. In the present study, the toxic effects of 2,4-dinitrotoluene (2,4-DNT), 2,6-dinitrotoluene (2,7-DNT) and a selection of their respective metabolites were examined using the 15-min Microtox™ (*Vibrio fischeri*) and 96-h freshwater green alga (*Selenastrum capricornutum*) growth inhibition tests. All of the compounds tested were less toxic than TNT. Using the Microtox™ assay, 2,6-DNT was more toxic than 2,4-DNT and the order of toxicity for 2,6-DNT and its metabolites was : 2,6-DNT $\geq$ 2A-6NT >> 2,6-DAT; whereas that for 2,4-DNT was: 4A-2NT > 2A-4NT > 2,4-DNT > 2,4-DAT. For the algal test, 2,4-DNT was more toxic than 2,6-DNT and the order of toxicity for 2,4DNT and its metabolites was: 2,4-DNT > 2,4-DAT $\cong$ 4A-2NT = 2A-4NT. The order of toxicity for 2,6-DNT and its reduced metabolites using the algal test was very similar to the Microtox™ bioassay. These results demonstrate that the reduced metabolites of 2,6-DNT tested in this study were less toxic than that of the parent compound, but certain partially reduced metabolites of 2,4-DNT can be more toxic than the parent molecule. These data put into question the general hypothesis that reductive metabolism of nitro-aromatics is associated with a sequential detoxification process.

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D4

PING[1] G., S.D. SICILIANO[1], G.I. SUNAHARA[1]

ECOTOXICOLOGICAL EFFECTS OF TNT (2,4,6-TRINITROTOLUENE) ON SOIL MICROBES: A COMPARISON OF RESULTS FROM A LABORATORY SPIKING EXPERIMENT AND A FIELD SAMPLING OF CONTAMINATED SITES

It has been recognized that soil microorganisms are important and ideal bioindicators of soil pollution due to their essential role in the maintenance of soil fertility and productivity, their intimate contact with the soil microenvironment, and their sensitivity to environmental contaminants. In this study, three sensitive and ecologically significant microbially-mediated processes, nitrification (NA), nitrogen-fixation (NFA) and dehydrogenase activity (DHA), were therefore chosen as the monitoring parameters of TNT ecotoxicity in soils. A laboratory spiking experiment was carried out with initial TNT concentrations of 0, 25, 50, 100, 200, 400, 800 and 1000 $\mu g.\ g^{-1}$ soil. Two garden soils of contrasting texture (sandy vs. clay) were used. IC_{50} (concentration causing 50% inhibition) was derived for the two soils and for the three measurement endpoints. Field soils were also sampled from three sites previously contaminated by TNT, and were analyzed for their NA, NFA and DHA, as well as TNT concentrations. These samples were taken from areas with no vegetation (seriously contaminated) and their surrounding areas covered by grasses (less contaminated). Toxic effects of TNT were related to its concentration in soil. Results obtained from the lab and the field were compared and the differences between them were discussed. A critical level of TNT in soil was suggested on the basis of the experimental results of this work.

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D5

FÉRARD[1] J.F., S. COTELLE[1], J.F. MASFARAUD[1]

BIOMARQUEURS DE PHYTOGÉNOTOXICITÉ - INTÉRÊT DU TEST *VICIA*-MICRONOYAU DANS DIFFÉRENTES ÉTUDES DE CAS

Les plantes supérieures permettent de détecter la présence de substances génotoxiques et/ou mutagènes dans diverses matrices solides de façon directe ou indirecte. La lixiviation de matrices solides permet de générer une phase liquide qui peut alors être le support de différents tests qui se caractérisent par différents critères d'effet. Nous nous sommes plus spécialement intéressés au test micronoyau sur racines secondaires de *Vicia faba*. Ce test réalisé, selon le protocole de Ma *et al.* (1995), a été appliqué à diverses matrices complexes (*e.g.* substances, sols contaminés, boues de STEP compostée ou non, déchets,..) et les résultats ont été comparés à d'autres tests de phytogénotoxicité, bioessais, biomarqueurs du stress oxydant (SOD, GR, POD et CAT).

Ces diverses études ont permis de mettre en évidence i) des relations concentrations-réponses typiques d'un effet cytotoxique se superposant (pour les fortes concentrations) à l'effet génotoxique, ii) une plus grande sensibilité du critère d'effet « micronoyau » par rapport à d'autres effets écotoxiques classiquement mesurés (*e.g.* élongation racinaire), iii) une plus grande sensibilité des critères d'effets sur plantes supérieures par rapport à d'autres essais plus classiques (test d'AMES par exemple) et iv) le plus grand intérêt du test *Vicia faba* qui fait l'objet d'une proposition de normalisation auprès de l'AFNOR.

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D6

ROCHELEAU[1] S., R. CIMPOIA[1], L. PAQUET[1], I. VAN KOPPEN[1], S.R. GUIOT[1], J. HAWARI[1], G. AMPLEMAN[2], S. THIBOUTOT[2], G.I. SUNAHARA[1]

TOXICITY EVALUATION OF A BIOSLURRY PROCESS TREATING SOILS SPIKED WITH EXPLOSIVES

The toxicity of four bioslurry reactors treating TNT- and RDX-spiked soil was evaluated. A Control bioslurry reactor was used to assess the endogenous toxicity of the process. A battery of ecotoxicity tests including several trophic levels was used: bacterial toxicity (Microtox™), phytoplanctonic growth inhibition (*Selenastrum capricornutum*), bacterial genotoxicity (SOS Chromotest), bacterial mutagenicity (Fluctuation test), terrestrial phytotoxicity (inhibition of *Lactiva salva* root elongation), earthworm (*Eisenia foetida*) mortality and growth inhibition. Bioslurry soluble and solid phases were separated by centrifugation in order to identify toxicity associated with each phase. Microtox™ toxicity values were initially very high in both bioslurry reactors spiked with TNT, in correlation with TNT concentration. Initial toxicity was also detected by algal growth inhibition, earthworm lethality, genotoxicity and mutagenicity tests. An endogenous toxicity of the bioslurry process was detected using the Microtox™ (soluble phase) and lettuce root elongation inhibition (soluble and solid phases) tests. In addition, the soluble phase of the Control bioslurry was genotoxic, suggesting that the bioslurry process may have contained potentially genotoxic compounds. At the end of the biotreatment, data showed that the bioslurry process reduced toxicity using all of the bioassays, except for earthworm lethality and growth inhibition tests in both RDX-spiked bioslurries. This study demonstrates the usefulness of a battery of toxicity tests to evaluate bioremediation processes.

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E1

MUNKITTRICK[1] K.R.

EVERYTHING I NEED TO KNOW ABOUT BIOMARKERS I SHOULD HAVE LEARNED IN PRESCHOOL

The recent explosion of interest in the potential of chemicals to disrupt endocrine processes at very low exposure levels will lead to the increased use of physiological tools in field studies. Physiological studies have not been fully developed for ecotoxicological applications and are underappreciated or poorly utilized. Field studies have historically focused physiological tools on direct impacts of specific chemicals, and usually on general indicators of health or exposure. The result has been that most surveillance programs have only used physiological tools for the assessment of exposure. Issues preventing wider development or acceptance of physiologically-based monitoring include terminology, focus, study design, application and interpretation. An increasing need to link responses in wild fish with the underlying ecological mechanisms means that physiological studies have to play a key role in the assessment of impact. This use of physiological studies requires a level of detail not previously warranted in field studies. Many of the steps required to properly use physiological tools are common sense, but are rarely applied. Limitations of physiological indicators will be discussed, as well as the requirements for the future development of physiological indicators of endocrine disruption.

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E2

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USE OF RAINBOW TROUT *(ONCORHYNCHUS MYKISS)* AND BROWN TROUT *(SALMO TRUTTA)* TO SCREEN HAMILTON HARBOUR WATER FOR ESTROGENIC EFFECTS

Hamilton Harbour is highly impacted by industrial and domestic waste. It receives sewage treatment plant (STP) effluent from several communities including the cities of Burlington and Hamilton. There has been much recent concern over the potential estrogenicity of some components of STP effluents including natural estrogens and the alkylphenols and their degradation products. We assessed the ability of Hamilton Harbour waters to induce vitellogenin (Vg) in juvenile fish. Vg was measured by ELISA. In the first of three studies, rainbow trout were caged at six sites in Hamilton Harbour and L. Ontario. Vg was measured in fish caged at sites in the Windermere Arm of the harbour. Those sites are within the zone of influence of Hamilton STP effluent and of several large industrial sites. In a second study, a group of rainbow trout was caged in the effluent mixing zone of the Burlington STP and another group was concurrently exposed to a dilution series of effluent from the Burlington STP in the laboratory. Vg was induced in the laboratory exposed fish by ≥50% effluent, but not in the field exposed fish. In the third experiment, rainbow and brown trout were caged at sites in the Windermere Arm of Hamilton Harbour. Fish caged at a site in nearby L. Ontario were used as field controls.

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E3

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COMPARISON OF INNATE IMMUNE PARAMETERS FROM *ONCORHYNCHUS MYKISS* CAGED AT VARIOUS SITES IN HAMILTON HARBOUR

A preliminary field study was conducted in the Hamilton Harbour to determine whether or not exposure, at sites known to be contaminated with high levels of polycyclic aromatic hydrocarbons (PAHs) and heavy metals, was sufficient to alter fish immune function. Caged fish (*Oncorhynchus mykiss*) were sampled after 7, 14, and 21 days of exposure from six sites designated by their proximity to highly contaminated sediments and various industrial and municipal discharges. Pronephros leukocytes were evaluated for phagocytic activity, oxidative burst, and surface immunoglobulin-positive B cell counts. Serum was collected to monitor lysozyme levels. All immune parameters were compared to fish sampled from a Lake Ontario control site. Both the phagocytic index and percent of phagocytizing leukocytes were reduced across time in fish sampled from the Harbour sites compared to the Lake Ontario control fish; oxidative burst was also reduced at two of these sites. B cell counts were not significantly affected across time at any of the sites, however, overall fish B cell numbers at three of the Harbour sites appeared to be lower than the Lake Ontario controls. Serum lysozyme levels were also affected across time, showing a significant reduction at two sites in the Harbour when compared with Lake Ontario control fish. These preliminary results indicate that innate immune parameters are altered in fish caged at various sites within the Harbour. Some of those alterations also appear to be time dependent.

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E4

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IMMUNOTOXICITY BIOMARKERS IN FISH : DEVELOPMENT VALIDATION AND APPLICATION IN FERAL POPULATIONS

Through the efforts of a number of different laboratories, a battery of immune assays is available to predict the immunotoxicity of different classes of Xenobiotics. These assays, originally developed in rodents, have been adapted for use in a variety of animal species. Our laboratory has investigated specific immune responses of fish for use as biomarkers to predict the potential toxicological impact of contaminated aquatic environments on inhabiting species. Among these markers are assays that assess immunopathology, cell-and humoral-mediated immunity, and host resistance against infectious bacteria. The utility of these endpoints as "biomarkers of effect" have been validated in laboratory studies by examining the effects of well-know metal and pesticide mammalian immunotoxicants in the small aquaria fish, Japanese medaka. These same immune parameters have also been examined in feral populations of smallmouth bass and have proven successful for predicting the immunotoxicological hazards associated with habitation in a chlorinated hydrocarbon-contaminated aquatic environment. For example, bass recovered from polluted sites had reduced (compared to reference site fish) phagocytosis antioxidant enzyme activity, and superoxide anion production by recovered kidney cells. Results of these studies demonstrate the utility of immunotoxicity biomarkers in fish for predicting the toxicological hazards associated with realworld polluted environments. Supported by U.S. Army Center for Environmental Health Research Contract. No. DAMD-17933059.

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E5

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WHERE HAVE OUR AMPHIBIANS GONE ? SUPPRESSION OF PHAGOCYTOSIS AND LYMPHOCYTE PROLIFERATION FOLLOWING *IN VITRO* EXPOSURE OF *XENOPUS LEUKOCYTES* TO HEAVY METALS

The worldwide amphibian decline has now been well substantiated. Though potential causes vary, pollution continues to gain ground. However, excluding lethality assays, studies conducted to determine the sublethal effects of environmental toxicants on amphibian physiology are few in number. It is this reasoning which prompted the beginnings of the present study; evolution of a sound laboratory model, *Xenopus laevis*, placing special emphasis in immunotoxicology. Because *Xenopus laevis* is not an indigenous frog species, as the first step we wanted to verify its sensitivity towards xenobiotics that are of concern for our environment and among those, heavy metals were selected first. As part of the natural immunity, the phagocytic activity in leukocytes was selected and was analyzed by flow cytometry. For the lymphocytes, their basic capability to proliferate upon antigenic stimulation was looked at by the mitogenic assay. Both functions were studied following *in vitro* exposure to methyl mercury and/or mercuric chloride.

Both assays were significantly suppressed at 10^{-6}M of methyl mercury while mercuric chloride significantly suppressed the mitogenic assay at 10^{-9}M. Although the sensitivity of *Xenopus* is still under scrutiny, these results clearly demonstrated the high sensitivity of immunological parameters of *Xenopus*, following exposure to trace amounts of mercury.

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E6

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IMMUNOMODULATION BY HEAVY METALS TESTED INDIVIDUALLY OR IN MIXTURES IN RAINBOW TROUT (*ONCORHYNCUS MYKISS*) EXPOSED *IN VIVO*

The objective of the study was to evaluate the effects of heavy metals, at environmentally relevant concentrations, on the immune response of rainbow trout. Trouts were exposed thirty days *in vivo* to cadmium chloride ($CdCl_2$), mercuric chloride ($HgCl_2$) or zinc chloride ($ZnCl_2$), individually or in the following combinations : $CdCl_2$ / $HgCl_2$; $CdCl_2$ / $ZnCl_2$; $HgCl_2$ / $ZnCl_2$ or $CdCl_2$ / $HgCl_2$ / $ZnCl_2$. After 30 days of exposure, non-specific cellular and humoral immune responses were studied through phagocytosis and respiratory burst or lysozyme activity and plasma immunoglobulin level, respectively. Moreover, the capability of lymphocytes to proliferate upon mitogenic stimulation was also measured. The results obtained reveal first of all the high sensitivity of the trout to heavy metals. Moreover, we have shown that taken individually, all three metals induce significant immunomodulations. However, the magnitude of these modulations following exposures to cadmium and mercury is significantly reduced when these metals are in combination with zinc, indicating a protection by zinc of cadmium or mercury-induced immunotoxicity.

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F1

HÉBERT[1] S.

QUALITÉ DES EAUX DU FLEUVE SAINT-LAURENT, 1990 À 1997

Les données physico-chimiques colligées de 1990 à 1997 à près d'une trentaine de stations d'échantillonnage, ont servi à caractériser, sur les plans spatial et temporel, la qualité des eaux du fleuve Saint-Laurent entre Cornwall et Québec. La qualité de l'eau est bonne jusqu'à la hauteur de l'île de Montréal, mais se détériore par la suite. Les principaux problèmes et pertes d'usage sont liés à une contamination bactériologique provenant des stations d'épuration de la CUM et de Longueuil qui, bien que dotées d'un traitement physico-chimique, ne désinfectent pas leurs eaux usées. La contamination bactériologique issue de ce secteur commence à s'estomper dans le lac Saint-Pierre, mais persiste jusqu'à la hauteur de Gentilly, à environ 100 km en amont de Québec. L'analyse des séries chronologiques montre qu'il y a eu, à la majorité des points d'échantillonnage, une baisse significative ($P<0,05$) de la conductivité et des concentrations de phosphore attribuable aux interventions d'assainissement réalisées dans les secteurs municipal et industriel; on observe également, à plusieurs endroits, une diminution significative de la turbidité, des matières en suspension et de la contamination bactériologique.

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F2

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L'UTILISATION DE CELLULES À DIALYSE ET DE MOUSSES AQUATIQUES POUR LE SUIVI DE LA QUALITÉ DES EAUX DU RICHELIEU

Le suivi des métaux et de plusieurs composés organiques toxiques dans les eaux de surface pose une difficulté majeure : ces substances n'y sont souvent présentes qu'en concentrations nettement inférieures à ce qu'il est possible de détecter avec les méthodes conventionnelles d'échantillonnage et d'analyse. Pour le suivi de ces substances, le ministère de l'Environnement et de la Faune utilise, entre autres, des mousses aquatiques et des cellules à dialyse, qui ont la faculté de concentrer les polluants. Des échantillons de mousses aquatiques (*Fontinalis dalecarlica*) sont prélevés dans un cours d'eau vierge et transférés dans les cours d'eau à l'étude, en amont et en aval des sources potentielles de polluants. Relevées après un mois d'exposition en rivière, les mousses aquatiques sont ensuite analysées pour les métaux, les BPC, les pesticides organochlorés et les dioxines et furannes chlorés. Les cellules à dialyse sont faites d'un tube souple et semi-perméable rempli d'hexane, un solvant organique. Elles ont la faculté de concentrer les HAP légers, les phtalates, les acides résiniques, les toluènes et d'autres composés benzéniques. Les cellules à dialyse et les mousses aquatiques ont permis de documenter la qualité de plusieurs cours d'eau du Québec (L'Assomption, Saint-François, Chaudière, Yamaska, Richelieu, Saint-Maurice) pour un grand nombre de métaux et de substances toxiques organiques. Les résultats obtenus à l'aide de ces techniques seront illustrés par le cas du Richelieu.

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F3

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LA CARACTÉRISATION DE L'ALUMINIUM DANS LA RIVIÈRE SAGUENAY

Les installations Sécal déchargent des effluents, qui contiennent de l'Al, dans la rivière Saguenay. Les concentrations de l'Al relativement plus élevées que le critère de qualité de l'eau pour la protection du milieu aquatique (87 μg/L de l'Al extractible) ont parfois été observées. L'objectif de ce projet est d'évaluer l'effet des rejets de Sécal sur la rivière Saguenay.

Nous avons effectué les analyses d'Al total et dissous, la détermination de l'Al monomère inorganique (Al_i) et une évaluation de la toxicité chronique des échantillons prélevés du milieu récepteur. Les essais de toxicité ont été effectués avec la tête-de-boule, l'invertébré *Ceriodaphnia dubia* et l'algue *Selenastrum capricornutum*. Trois stations de référence ont été sélectionnées en amont des installations de Sécal, avec une quatrième située sur la rivière Chicoutimi. Trois stations ont été situées en aval des installations de Sécal. Les prélèvements ont eu lieu en printemps, en été et en automne 1997.

Les concentrations de l'Al total et dissous sont plus élevées en aval des installations Sécal. Cependant, les teneurs aux stations de référence sont généralement supérieures aux critères pour l'Al. Les concentrations d'Al_i sont faibles en aval des installations de Sécal et sont généralement comparables aux sites de référence de l'étude. Les expositions aux échantillons des stations en aval des installations de Sécal n'ont causé aucun effet sur la croissance de l'algue, sur la reproduction de *Ceriodaphnia* ou sur la croissance du mené.

Les critères de la qualité de l'eau pour l'aluminium devraient davantage tenir compte de l'Al_i, la forme biodisponible de cet élément.

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F4

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INDICE BIOTIQUE À INTÉGRITÉ PISCICOLE (IBIP) POUR ÉVALUER LA QUALITÉ ÉCOLOGIQUE DES ÉCOSYSTÈMES LOTIQUES

Afin de répondre à une nouvelle directive de la Communauté européenne qui vise à classer les milieux aquatiques en fonction de sites de référence de haute qualité écologique, nous tentons de développer un indice global de qualité écologique des cours d'eaux (Indice Biotique d'Intégrité Piscicole : IBIP) basé sur l'étude de la structure des communautés piscicoles du bassin hydrographique de la Meuse, qui s'inspire du concept de l'Index of Biotic Integrity (IBI) développé initialement dans le Middle West américain. L'échantillonnage par pêche électrique (deux passages consécutifs sur 150 m) de 87 stations situées sur les cours d'eau supérieurs et moyens ainsi que le relevé des adaptations de l'IBI à d'autres régions ont permis de retenir préalablement douze paramètres.

L'étude de la méthodologie d'échantillonnage (effet du nombre de passages, de la longueur échantillonnée et de la proportion des différents mésohabitats sur les paramètres retenus) a conduit à une standardisation de la méthodologie : pêche électrique en un seul passage sur un secteur de 150 m et présentant une variété de mésohabitats (radier, plat et fosse). La validation des paramètres, sur base de la méthodologie retenue, a été abordée par une analyse statistique appropriée (Analyse en Composantes Principales) et par l'étude de l'effet de différents types de pollutions sur les paramètres de l'IBIP, conduisant ainsi à la sélection de six paramètres classés en trois catégories : les paramètres indicateurs de la richesse spécifique (nombre d'espèces natives et nombre d'espèces benthiques), les paramètres indicateurs de la qualité de l'eau (pourcentage d'individus intolérants et nombre d'individus chabot/nombre d'individus chabot + loche) et enfin, les paramètres indicateurs de la qualité de l'habitat (pourcentage d'individus pondeurs spécialisés et présence-absence d'alevins, de juvéniles et/ou d'adultes chez l'espèce dominante et intolérante). L'indice est utilisable dans l'évaluation globale des cours d'eau de la partie wallonne du bassin mosan (excepté la Meuse et la Sambre).

L'IBIP propose des critères quantitatifs pour apprécier la qualité écologique des cours d'eau et aider à l'interprétation de données biologiques complexes. En pratique, l'interprétation du score total (et donc de la classe d'intégrité qui en découle) ne devra se faire qu'en examinant précisément les différents paramètres de l'IBIP. En association avec d'autres indicateurs physico-chimiques et biologiques, il permet une évaluation fiable de la qualité globale des cours d'eaux wallons. L'application à d'autres cours d'eau du bassin mosan ainsi qu'à d'autres bassins versants de la même éco-région est en cours dans le cadre d'un projet Life subsidié par la Commission Européenne en vue de normaliser l'outil.

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STATUS OF BENTHIC COMMUNITIES IN AREAS OF CONCERN IN THE GREAT LAKES

In the late 1980s and early 1990s, benthic communities were collected from several Areas of Concern (AOCs) and areas of interest throughout the Great Lakes. In order to estimate the degree of impairment in these test locations, benthos were collected from «least» impaired reference locations in the early 1990s. Benthic communities from test locations were evaluated relative to reference sites that had similar background physical and chemical attributes. We determined the probability that compositional indices of benthic communities from test locations fell within the «normal range» of variation of compositional indices from matching reference locations. Index values falling inside the normal range were used as evidence that benthic communities were not impaired, while index values falling outside the normal range were used as evidence of impairment. Benthic communities were classified impaired in most areas along the Canadian shoreline of Lake Ontario, but specifically in Hamilton Harbour, Toronto's harbour front and the Bay of Quinte. In Lake Erie, some impairment was evident in the vicinity of Long Point. All other areas in Lake Erie were classified as non-impaired. Harbours in Georgian Bay generally showed at least some impairment, as did harbours in northern Lake Superior.

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LAND USE AND THE DECLINE OF FRESHWATER MUSSEL SPECIES IN LOWER GREAT LAKES WATERSHEDS

Freshwater mussel populations are declining in diversity and abundance at an alarming rate throughout North America. Habitat destruction and water pollution are at least partly responsible for threatening 55% of the 300 mussel species on this continent, as well as their fish hosts. Change in water quality parameters, pesticide and chemical concentrations and seasonal water levels may be associated with the changes in species diversity, fluctuations in population health and stability and the occurrence of endangered species. A 1997 survey of three rivers in southwestern Ontario showed that 50% of native mussel species have been extirpated or are in serious decline. In an attempt to understand some of the specific pressures on these species, an inventory of land use in the Grand River watershed was assembled and correlated with the diversity and composition of mussel communities, population stability (abundance, size class structure) of the various species, and measures of physiological health in two common species, *Lasmigona costata* and *Pyganodon grandis*. *L. costata* is found in the main stem of the river while *P. grandis* is mainly in small tributaries, a fact which allows them to be used as indicators of both point and non-point source pollution effects throughout the system. Establishing the correlation between species health and specific pollutants will provide the necessary information to restore habitats that can provide refugia for the species endangered throughout the Great Lakes region.

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WEIGHT LOSS AND ABNORMAL NET CONSTRUCTION IN A NET SPINNING CADDISFLY (*HYDROPSYCHE*) LARVAE EXPOSED TO ELEVATED CONCENTRATIONS OF ZINC

Hydropsyche betteni larvae were collected from two locations near a New Brunswick mine site in November 1996. The first collection site was located approximately 50 m upstream of waste rock originating from the mine. The second collection site was located a further 3 km upstream and was well removed from anthropogenic mine sources. Larvae were transported to Trent University, Ontario and exposed for seven weeks to elevated concentrations of zinc (5, 10, 20 & 40 mg Zn/L) introduced as zinc sulfate. Live weights and net construction were recorded on individuals 4 times during the exposure period. Although the measured zinc concentrations of the test water were much greater than zinc water quality objectives, the LC_{50} was greater than 40 mg Zn/L @ 7 weeks. However, larvae lost weight when exposed to increasing concentrations of Zn or with increasing lengths of exposure, while negative control larvae gained 6% during this time. Those exposed to 40 mg Zn/L lost approximately 19% to 23% of the original body weight. The frequency of abnormally constructed nets increased with both increasing concentrations of Zn and increasing duration of exposure. The percentage of abnormally constructed nets increased to approximately 30% for those exposed to 40 mg Zn/L as compared to less than 5% for the control treatments. Weigh loss and net construction were more sensitive than mortality to the toxicological impacts of elevated zinc and may present a potential use as cost-effective end-point measurements for stream dwelling Hydropsychids.

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G2

BÉZAIRE-DUSSAULT[1] E., R.C. PLAYLE[2] , R.S. MCKINLEY[1]

EFFECT OF SOFT WATER AND ALUMINUM ON CARDIAC OUTPUT AND SWIMMING PERFORMANCE OF RAINBOW TROUT

Previous studies have shown that acclimation of salmonids to aluminum in acidic, soft water may induce a reduction in swimming capacities. Aluminum induced gill damage and other modifications in gill structure may result in decreased oxygen uptake and therefore cause earlier oxygen debt when sustained swimming is required. We attempt to demonstrate these changes using cardiac output devices. Rainbow trout (*Oncorhynchus mykiss*, ~ 250 g) were acclimated to synthetic soft water (Ca ~ 50 mM) for two weeks. Their cardiac output was monitored at different swimming speeds in a modified Blaska chamber, and compared to cardiac output of fish acclimated to hard water (Ca ~ 5 mM). Similarly, the effects of low concentrations of aluminum (~ 0.0-7.5 mM) and low pH (~5.0) were assessed in soft water. Blood samples were taken and analyzed for plasma Al, major ions, blood gases, hematocrit and blood lactate concentration. Gill samples were removed and analyzed for Al. We intend to correlate any differences in cardiac output and swimming performance with water chemistry and physiological parameters.

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IS NICKEL SUBSULFIDE AN IMPORTANT ENVIRONMENTAL CONTAMINANT?

Nickel subsulfide is recognized to be of major importance in occupational health in association with nickel mining and processing. However, such water insoluble nickel compounds have commonly been considered to be of little or no importance in aquatic toxicology. In pilot studies on the chronic effects of nickel subsulfide on fish, we noted a marked accumulation of nickel (Ni) in the skin of rainbow trout. Juvenile female rainbow trout, *Oncorhynchus mykiss*, were further injected intraperitoneally with 100 mg nickel subsulfide. After twenty four days of exposure the fish were decapitated and skin and scale samples were prepared for histological examination. Skin and scale samples of exposed fish displayed enhanced pigmentation caused by an increase of the number of dermal melanocytes per surface area (μm^2) and by dispersion of melanosomes in the dermal melanocytes. In addition, changes in mucous composition in the mucous cells were observed, suggesting the sensitivity of the skin to particulate Ni. These initial results indicate that nickel subsulfide could be an important environmental contaminant in association with nickel mining.

(Supported in part by the Toxic Chemicals Program, Department of Fisheries and Oceans).

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OXYPAH LOADING AT PAH CONTAMINATED SITES IN SOUTHERN ONTARIO

On exposure to light many PAHs undergo oxidation reactions, forming products such as quinones and hydroxyquinones (oxyPAHs). PAH photoreactions can occur in both the atmosphere and aquatic systems, with subsequent deposition of photoproducts to sediments or adsorption to suspended particulate. OxyPAHs are frequently more cytotoxic to invertebrates, plants and micro-organisms than parent PAHs, and some have been shown to be potent mutagens. Thus, oxyPAHs can present an additional source of biological impact at PAH contaminated sites. Sediment samples and water column particulate samples were collected from several southern Ontario sites of known PAH contamination, plus a reference site with low PAH levels. PAHs and oxyPAHs were isolated from sediment samples by hexane:acetone extraction, and separated using a two-step fractionation procedure. An initial fractionation was conducted by high performance, low pressure liquid chromatography using a gel permeation column, followed by a reverse phase HPLC separation and diode array detection. The 2-D separation procedure allowed for isolation and non-destructive identification of oxyPAHs and PAHs from within the sample matrix. The relative toxic contributions were compared for PAHs and oxyPAHs present within the sediment samples, and it was shown that oxyPAHs can be significant contributors to cytotoxicity in contaminated sediments.

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PERFORMANCE OF BIOLOGICAL TESTS IN ESTIMATING THE SUBLETHAL TOXICITY OF MINING EFFLUENTS

Under the Aquatic Effects Technology Evaluation Program (AETE), laboratory sublethal toxicity tests have been evaluated for possible future use in the EEM component of the amended federal regulation on effluent discharges from metal mining operations. In 1994, a literature review was conducted by an independent toxicologist to evaluate and rank 13 candidate sublethal toxicity tests. From this review, a short-list of 8 tests was recommended for further assessment during the AETE mine effluent testing phase. Between 1995 and 1997, three laboratory testing studies were conducted using various mine effluents from across Canada to critically assess the performance of the short-listed toxicity tests. After the first two testing rounds, the short-list of tests was reduced to 4 test procedures (i.e. *Ceriodaphnia* survival and growth; fathead minnow survival and growth; *Selenastrum* growth inhibition; *Lemna* growth inhibition) which were evaluated in the third study (i.e. the sublethal testing component of the final AETE field program). The effluent test results for 19 mine locations will be presented in summary and criteria used to reduced the number of short-listed tests will be discussed.

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DEVELOPMENT AND APPLICATION OF BIOASSAYS FOR AQUATIC ENVIRONMENT MANAGEMENT IN THE NORTH EAST PACIFIC REGION

With rapid industrialization and urbanization along the coastal areas of the North West Pacific regions, the pollution of the North Pacific Sea has been an international concern. To preserve this marine environment , which provides abundant natural resources to these regions, international programs including monitoring, control of land-based discharges and dumping activities, have been initiated. In this respect, the bioassay-based approach has received increased attention along with the traditional chemical specific approach for assessment and control of complex wastes. Although there is so far no regulatory environmental standard (i.e. effluent standard) based on bioassays, some standard toxicity tests have been developed and the use of bioassay has generally been increasing in these regions within the last ten years. This paper presents a state of the art update on the development and application of bioassays for aquatic environmental management of countries which include Japan, China, Korea and Russia.

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CONSTRUCTION D'UN INDICE D'ÉCOTOXICITÉ DES EFFLUENTS PAR RÉGRESSION PLS

Les agences de l'Eau, en France, souhaitent mettre en œuvre des essais d'écotoxicité chronique pour le contrôle des effluents toxiques rejetés dans le milieu aquatique. Des études préalables avaient montré la pertinence d'une telle approche par rapport aux pratiques internationales et la capacité des laboratoires français de réaliser de tels essais en routine.

Nous avons basé notre étude sur un jeu de données de trente effluents sur lesquels cinq essais d'écotoxicité (dont deux chroniques) et deux essais de génotoxicité avaient été réalisés. Notre démarche a consisté à appliquer un traitement des données unique pour tous les essais en calculant les concentrations effectrices 10% (CE_{10}). Puis nous avons transmis les résultats à un panel d'experts qui s'est penché sur ce jeu test et nous a apporté des informations qualitatives sur les essais qui nous ont servi à mieux fonder notre choix d'une batterie. D'autre part le classement des effluents par les experts nous a été utile pour fabriquer notre indice.

Nous avons ensuite utilisé une méthode de regression particulière : la régression PLS qui permet de trouver une formulation linéaire stable et pertinente à partir de variables corrélées entre elles. Nous avons pu proposer une formule simple qui calcule un indice d'écotoxicité très proche du jugement des experts, en donnant un poids plus fort aux essais sur *Ceriodaphnia dubia* et sur *Pseudokirchneriella subcapitata*. Nous avons comparé notre indice à l'indice BEEP développé au Canada et obtenu une très bonne concordance des deux indices.

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AQUATIC TOXICITY OF UNTREATED AND TREATED TEXTILE MILL EFFLUENTS

Textile Mill Effluents (TMEs) are one of 25 substances on the Second Priority Substances List under the Canadian Environmental Protection Act (CEPA). An ecological risk assessment (ERA) is being conducted to determine whether TMEs are "toxic" as defined by CEPA. An important measurement endpoint for the ERA is acute and chronic aquatic toxicity tests of whole effluent samples from textile mills conducting a range of operations. In the late winter and spring of 1998, untreated and/or treated effluent samples were collected from 8 textile mills in eastern Canada conducting woven fabric finishing, knit fabric finishing or wool finishing operations. All untreated effluent samples, in both winter and spring, were acutely toxic to *Vibrio fischeri* and *Ceriodaphnia dubia* and had sub-lethal effects which included reproductive impairment in *C. dubia* and growth impairment in *Selenastrum capricornutum*. In most cases, treated effluent samples from secondary or tertiary treatment systems eliminated toxicity. An exception however, was an aerated lagoon system which produced effluent slightly toxic to *C. dubia*, had a very slight inhibitory effect on reproduction in that species, was slightly toxic to *S. capricornutum* and was toxic to *V. fischeri*. There was significant correlation between all of the bioassays conducted; overall the Microtox™ acute and chronic tests were the most sensitive bioassays, the alga test was the least sensitive bioassay.

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AMMONIA TOXICITY IN ALKALINE MINE-MILL EFFLUENT: THE INFLUENCE OF ATMOSPHERIC CARBON DIOXIDE ON PH AND UNIONIZED AMMONIA

At Sudbury, ore processing effluents are generally treated to precipitate nickel and other metals by adding calcium hydroxide (target pH 10.5). After August 1997, Ontario restricted effluent pH to 6.0-9.5, and in static toxicity tests *Daphnia magna* and rainbow trout survival must be ≥ 50%. Undiluted effluent from the CCWWTP (Copper Cliff Wastewater Treatment Plant, INCO Ltd.) previously exhibited pH >10, 510 mg/L total ammonia/ium, and toxicity test failures. The primary stressor was apparently unionized ammonia, and it was hypothesized that lowering effluent pH would control toxicity by favoring ammonium ions. While Toxicity Identification/ Evaluations generally supported these hypotheses, uncertainty remained because low mortality often occurred when unionized ammonia toxicity was expected. We report here chemical and toxicity studies conducted on CCWWTP effluent to identify the final pH most cost effective for lowering toxicity, within the pH 6.0-9.5 criterion, and to investigate whether secondary factors influenced toxicity. Results indicated that toxicity reflected elevated pH and unionized ammonia, and that few test failures would occur in CCWWTP effluent adjusted to pH 8.7-8.9. Effluent pH often declined spontaneously during toxicity tests, but the time frames of pH declines were inconsistent. Most mortalities occurred early in test periods, and high mortality rates were infrequent when observed pH was < 9. Early pH declines occurred in samples exposed to atmospheric carbon dioxide, usually via aeration; apparently hydroxide ions were replaced by bicarbonate ions. Toxicity test aeration protocols should be revised to ensure both consistency and due consideration for carbon dioxide as well as oxygen.

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SYNTHESIS OF THE AQUATIC EVALUATION TECHNOLOGY EVALUATION (AETE) PROGRAM

The purpose of the AETE program was to evaluate methods and technologies that would be effective at measuring the aquatic impacts of mining operations at the least cost. The AETE program spanned a four year time period beginning in 1994, with a budget of $3.1M funded by CANMET and the Mining Association of Canada (MAC). Within the AETE program over 20 individual technical evaluations were completed as well as three years of field studies at mine sites across Canada. The AETE was comprised of three components:1) sediment and water monitoring, 2) toxicity testing and 3) biological effects. The program was designed to select technologies or approaches that could answer one or more of the four questions:

Are contaminants entering the system?
Are the contaminants bioavailable?
Is there a measurable biological response?
Are the contaminants responsible for this response?

A significant contribution of the AETE findings is integration and examination of relationships between different monitoring components to address the last question. For example, the relationship between sediment chemistry, sediment toxicity and biological communities (benthos, fisheries) was examined. The recommendations on various methods may be incorporated into an environmental effects monitoring program for the mining sector. The AETE program is summarized in one Synthesis Report which will be the subject of this presentation.

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H2

FARARA[1] D.G., P. MCKEE[1], D. R. HART[1], B. SANDER[2]

AETE 1997 FIELD EVALUATION OF AQUATIC MONITORING METHODS AT FOUR CANADIAN MINE SITES

In 1996, literature and preliminary field evaluations were undertaken at seven mines sites across Canada, three of which were selected for the 1997 field evaluation program (Heath Steele, N.B.; Westmin Resources, Myra Falls, B.C.; Dome Mine, Ontario). A fourth site was added in 1997 (Mattabi Mines, Ontario). The objective of the 1997 field evaluations was to evaluate the cost effectiveness of selected aquatic monitoring methods to determine if contaminants were entering the systems, if they were bioavailable, if there was a measurable biological response and if contaminants were causing the response. The monitoring methods that were evaluated included: total and dissolved aqueous metals; total and partial sediment metals, and acid volatile sulphide and simultaneously extracted metals; sediment toxicity tests (*Hyalella azteca, Chironomus riparius, Tubifex tubifex*); metals and metallothionein in fish tissues (gill, liver, kidney, muscle, viscera in small bodied fish); fish population/community responses (catch/biomass per unit effort, organ size, fecundity, length and weight); benthic community responses (number of taxa, density, indicator taxa) and effluent toxicity tests (*Lemna minor, Ceriodaphnia dubia, Selenastrum capricornutum, Pimephales promelas*).

Overall, the most cost-effective monitoring methods were considered to be total aqueous metals; total sediment metals; tissue metals (muscle, viscera, liver); the sediment toxicity test *Hyalella azteca*; fish catch/biomass per unit effort, growth, weight and organ size; benthic community measures (density and indicator taxa); and the effluent toxicity tests *Ceriodaphnia, Pimephales* and *Selenastrum*. The other monitoring methods were either not effective, equally effective but more costly, or equally effective but not presently commercially available.

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H3

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EVALUATION OF SEDIMENT EXTRACTION PROCEDURES AND THE SEDIMENT QUALITY TRIAD AT THREE CANADIAN MINE SITES

The Aquatic Effects Technology Evaluation (AETE) program is the product of a mining industry-government partnership designed to identify various methods suitable for assessing aquatic environmental effects from mining activity. In a 1997 field program carried out under the AETE Program, evaluations were carried out on how well various sediment chemistry measurements correlated with biological impact. The study was based on sediment chemistry, benthic macroinvertebrate community structure and sediment toxicity as determined in aquatic environments near the Dome gold mine (Timmins, Ontario), the Myra Falls base metal mine (Myra Falls, B.C.) and the Mattabi base metal mine (Ignace, Ontario).

Metal geochemistry in the sediments was evaluated by metal extraction using nitric acid/hydrogen peroxide (total metals), hydroxylamine hydrochloride (iron/manganese oxide-bound metals) and acid volatile sulphide/simultaneously extracted metals (AVS/SEM). Benthic and sediment toxicity responses were correlated with total and oxide-bound metal fractions to a similar degree, while relationships with SEM/AVS ratios were less evident.

Linkages between biological impact and total metal concentration differed in strength and character from site to site, apparently reflecting variation in metal geochemistry and bioavailability. The Sediment Quality Triad showed that, overall, sediment toxicity and benthic communities were responsive to sediment chemistry at all three mine sites. However, benthic and toxicity responses tended to be associated with different physical and chemical properties of sediment, and individual chemistry-biology-toxicity relationships were not always statistically significant. These observations may relate to variable metal bioavailability from site to site and the influence of habitat conditions on benthic response.

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H4

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TOXICITY IDENTIFICATION/REDUCTION EVALUATIONS FOR THE CANADIAN MINING INDUSTRY

The Aquatic Effects Technology Evaluation Program commissioned a study to evaluate and summarize the experience of the Canadian mining industry with Toxicity Identification/Reduction Evaluations (TI/REs). The objectives included; i) completion of a critical evaluation of the quality of TI/RE data, ii) conducting a survey to evaluate the utility of the TI/RE strategies. Of the 53 mines that responded to the survey, 25 reported having discharged a toxic effluent at some time. Of those mines reporting toxic effluents, 7 (28%) conducted a TRE and 17 (76%) conducted one Phase I TIE. Very few reported testing beyond the Phase I characterization. Of the 17 completed TIEs, 6 (35%) successfully identified the substance(s) responsible for effluent toxicity. Four TI/RE case studies (CS) were also selected for detailed review. In CS #1, a copper/zinc mine, the primary toxicants were identified, but secondary toxicants were suspected. The mine closed, but effluent continues to be discharged and is occasionally toxic. In CS #2, a uranium mine, the primary toxicant identified, modifications were made to process and effluent toxicity was eliminated. In CS #3, a copper/nickel mine, the primary toxicant was identified, but secondary toxicant(s) were unknown. pH adjustment was added to treatment and toxicity was reduced. Mine personnel felt the conclusions were based mostly on speculation. The effluent is nonlethal to trout, but partial daphnid mortalities are still observed. In CS #4, a gold mine, the general characteristics of suspected toxicant(s) were identified, a full treatment plant was built, however, the effluent is still toxic.

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AQUATIC TOXICITY ASSOCIATED WITH DIAMOND MINING 1

Diamond mining is a new resource industry in Canada. Although the process to extract the diamonds from the ore (kimberlite) is chemical free, there is a general perception that diamond mining has the potential to cause significant adverse environmental effects. A study was commisioned by BHP Diamonds inc. with the following objectives : determine the acute and chronic toxicity of kimberlite solutions to aquatic organisms ; isolate and identify the toxic components associated with kimberlite solutions, determine the bioavailability of toxic chemicals to fish and determine the organ/tissue specific effects of kimberlite solutions on fish. This presentation gives an overview of the BHP Diamond mining process along with environmental concerns wich have been levied by government and the general public. Details of our study, designed to address these concerns will be presented.

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AQUATIC TOXICITY ASSOCIATED WITH DIAMOND MINING 6

Mature rainbow trout were exposed to solutions of kimberlite ore (50- and 500 mg/L) for up to 30-days. Following exposure, fish were sacrificed and subjected to chemical and biomarker analyses as well as internal and external examination. Chemical analyses included metals determination in liver, kidney, gill, liver and bile. Biomarkers examined included: testosterone, estradiol, cortisol (blood serum), metallothionein induction (liver, kidney, gill), phagocytosis and intracellular superoxide production (kidney), B- and T-lymphocyte proliferation (spleen), hematocrit, leukocrit and blood cell differentials (whole blood). The results of the biomarker, and chemical analyses will be discussed in relation to findings obtained from the internal and external examination of fish. The use of biomarkers as a measure of kimberlite exposure will be discussed as well as assessing the impact diamond mining has on the aquatic receiving environment.

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H7

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CONSIDERATIONS FOR MONITORING AQUATIC EFFECTS OF MINE OPERATIONS IN HONDURAS / EFFECTS OF RESOURCE UTILIZATION : MINING, FORESTRY AND AGRICULTURE

Mineral deposits in the central region of Honduras have received increased international interest recently. Mine development in Honduras is governed by accepted international standards and practices. Monitoring of aquatic effects of mining is complicated by economic, social and legislated factors not commonly encountered in Canada.

The utilization of natural streams for domestic purposes, such as laundry and personal hygiene, results in water quality impacts as well as the physical disturbance of substrates. These coexisting uses of aquatic resources must be considered in mine planning and effects monitoring.

Geothermal groundwater upwellings are associated with some gold deposits in central Honduras, and introduce thermal and mineral inputs to the receiving aquatic systems. Generic water quality objectives would be inappropriate in these situations where development of site specific water quality objectives would be suitable. The unique aspects of local concerns such as water supply, quality, treatment, release, recycling, and sewage treatment must also be taken into consideration during mine plaming and aquatic effects monitoring in central Honduras.

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LIBER[1] K., D. WANG[1], S. SOBEY[1]

APPLICATION OF THE SEDIMENT QUALITY TRIAD FOR EVALUATING THE IMPACT OF A URANIUM MINE EFFLUENT ON BENTHIC COMMUNITIES IN NORTHERN SASKATCHEWAN

A project was undertaken to evaluate the cumulative effects of metal-enriched effluent from the Rabbit Lake uranium mine in northern Saskatchewan on sediment quality and benthic community structure in downstream, effluent-receiving environments. Previous work conducted by the Province of Saskatchewan at this site had indicated that adverse effects may have been occurring, but details and causes had not been thoroughly investigated. Available chemistry data suggested that metals, not radiation dose, may have been responsible. The present study was designed to determine if the sediments were toxic to benthic invertebrates and if effects on the benthic community had occurred, to identify the possible causes of toxicity, and to establish sediment toxicity thresholds for metals of concern based on bioavailable metal fractions.

Results from seven sampling sites showed a correlation between sediment metal concentrations and both toxicity in laboratory bioassays with *Hyalella azteca* and *Chirnomus tentans* and changes in benthic community structure. Uranium appeared to be primarily responsible for the observed effects, with lesser contributions by nickel and arsenic. Subsequent spiked-sediment toxicity tests further supported the significance of uranium in the expression of *in situ* sediment toxicity. The significance of pore water vs. total metal concentrations for interpreting sediment toxicity and the importance of binding phases, such as acid volatile sulfides and organic carbon, for modifying metal bioavailability and toxicity will be discussed within the context of this project.

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H9

PRAIRIE[1] **R.**

MÉTAUX DANS LES SÉDIMENTS : RÉPONSES BIOLOGIQUES OBSERVÉES À PROXIMITÉ D'ACTIVITÉS MINIÈRES ET MÉTALLURGIQUES

Depuis plus de deux décennies, plusieurs divisions de la compagnie Noranda ont effectué des études permettant de caractériser l'impact de leurs activités sur le milieu récepteur aquatique. Compte tenu que la portion particulaire des métaux présents dans les effluents miniers ou dans les retombées atmosphériques se retrouve éventuellement dans les sédiments des plans d'eau situés en aval, l'évaluation de la qualité des sédiments a fréquemment été effectuée dans le cadre de ces études.

La présentation dressera une vue d'ensemble de ces résultats d'études s'étalant sur dix ans et ayant été effectuées à proximité de six sites d'activités de la compagnie. Ces sites reflètent une grande variété de différents milieux récepteurs: lacs et rivières du Bouclier canadien , milieu d'eau douce (fleuve St-Laurent) et milieu marin (Golf du St-Laurent et Baie des Chaleurs). Parmi les aspects étudiés à ces sites, on retrouve la physico-chimie des sédiments à différentes profondeurs, des analyses d'extraction séquentielle et d'acide volatile à l'acide, l'analyse des communautés benthiques et des tests de toxicité effectués sur ces sédiments. L'intégration de ces résultats permet de jeter un regard nouveau sur l'effet des métaux présents dans les sédiments sur la faune benthique (résidente et de laboratoire), et ce par rapport aux critères de qualité de sédiments actuellement en vigueur

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J1

VANDERMEULEN[1] H.

THE DEPARTMENT OF FISHERIES AND OCEANS' TOXIC CHEMICALS PROGRAM

The Canadian Department of Fisheries and Oceans (DFO) has a long history of supporting field and laboratory based research on toxic substances in its regional science institutes. With the demise of federal "Green Plan" funding at the end of fiscal year 96/97, DFO developed an Environmental Science Program to co-ordinate and fund its Toxic Chemicals Program (TCP). The management and research involved with the TCP will be described, along with an upcoming workshop in Ottawa on the program.

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J2

PAKENHAM[1] M.

PARTNERS IN IMPROVING CANADA'S AQUATIC ENVIRONMENT

Recreational boaters are environmentalists... whether they know it or not. Activities on the water are often driven by aesthetics and the enjoyment of nature. As the boating public becomes more informed about their impact on the aquatic environment, the more likely it becomes that they will modify their behaviour in a positive way, making good decisions for the right reasons.

The Department of Fisheries and Oceans - Coast Guard has "protecting the aquatic environment" as one of its primary missions. The Green Boat Program is a new, multi-faceted initiative to educate recreational boaters and small fishing vessel operators about reducing their impact on the aquatic environment. The Green Boat Program is a composite of public education initiatives, Green Boat kits, Green Boat checks and regulations all based on partnership principles.

At the very centre of the Canadian Coast Guard's approach is the belief that protecting the aquatic environment is a shared responsibility. The fulfilment of the partnership process occurs when each boater becomes a steward of the environment; feeling a personal responsibility and taking individual action to improve the aquatic environment.

Faced with reduced resources and increased demands, the Canadian Coast Guard - Green Boat Program uses existing resources well, and co-ordinates effective working partnerships with the boating community. A recipe for success and cleaner environment? It's looking better all the time.

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J3

SAINT-LOUIS[1] R., S. DE MORA[1], E. PELLETIER[2], I. MIKAELIAN[3]

RECENT BUTYLTIN CONTAMINATION IN BELUGA WHALES (*DELPHINAPTERUS LEUCAS*) FROM THE ST.LAWRENCE ESTUARY

Despite the strict regulations on the use of organotin-based paints on boat hulls in Canada and many other developed countries, contamination of marine organisms by tributyltin (TBT) is still observed. Recently, a research group from Japan has reported on the contamination of cetaceans and pinnipeds by organotins. The unexpected findings of considerable TBT levels in marine mammals prompted our own investigation of the contamination of higher trophic organisms of the St. Lawrence estuary, namely the beluga whales. The St. Lawrence estuary is an important shipping channel, being the entrance for large commercial ships to the St. Lawrence waterway. Since the liver is a target organ for the accumulation of TBT in marine mammals, we analysed the liver of beluga whales found stranded along the estuary shores in the last years. All specimens had their liver contaminated by TBT and its breakdown products in the range 0.015 - 0.9 ppm, the concentrations being similar to those reported for cetaceans from Japan and the Atlantic coast of USA. The butyltin compounds were detected in the liver of one neonate; the *in utero* tranfert of TBT from the mother to the foetus is thus possible. The results indicate that the partial ban on TBT-based paints is ineffective in protecting higher trophic marine organisms from TBT contamination. The potential adverse effects of TBT on beluga whales will be discussed together with the possible pathways of uptake of TBT.

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J4

FOURNIER[1] M., V. DEGAS[2], P. LAPIERRE[2], S. DE GUISE[2], D. MARTINEAU[3] , P. BÉLAND[4], P. BROUSSEAU[5]

IMMUNOTOXICOLOGICAL STUDY IN BELUGA WHALES

Over the last decades, high concentrations of environmental contaminants such as PCBs have been measured in the tissues of many species of marine mammals from different parts of the world. Even though many deleterious effects of these compounds have been reported in laboratory animals, the overall risk associated with these contaminants in wild animals is still not clearly understood. However, necropsy of St. Lawrence beluga showed numerous severe and disseminated infections with rather mildly pathogenic bacteria. Moreover, 37% of all the tumours reported in cetaceans were observed in St. Lawrence beluga whales. Indeed, both observations suggest immunosuppression. The aim of the study was to determine if contaminants present in fat tissues of beluga might provoke deleterious effect to their immune system if under some circumstances they are released into the circulation. To assess their immunotoxic potential, rats were fed for two months on a diet in which the lipids originated from the blubber of either highly polluted St. Lawrence beluga or relatively uncontaminated arctic belugas. Then, multiple immune responses were monitored. Those include phagocytosis, plaque forming cells, oxidative burst, natural killer cells, immunophenotyping and mitogenic assays. The results obtained show that only the humoral response of rats was impaired by the treatment. By combining all these information, we propose possible mechanisms of action to explain potential long-term consequences of environmental pollution.

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J5

JACKMAN[1] P.M. , K.G. DOE[1]

TOXICITY OF AZAMETHIPHOS AND CYPERMETHRIN, AND ENVIRONMENTAL RISK FROM THEIR USE AS SEA LICE CONTROL CHEMICALS FOR ATLANTIC SALMON AQUACULTURE SITES

A two-phase field study was conducted in 1996 and 1997 to evaluate the environmental risk from the use of azamethiphos and cypermethrin as sea lice control chemicals for Atlantic Salmon aquaculture sites. Each study consisted of three components: survey of the scientific literature on the toxicity of the therapeutic agent to aquatic organisms; laboratory screening of the toxicity of the chemical to a wide variety of marine organisms in order to choose a representative sensitive organism for the field study; and toxicity testing of samples taken from treated net pens and environmental samples taken from the plume for as long as five hours after release from the net pens. It was found that azamethiphos posed little risk once released from the net pens, while cypermethrin posed a toxic risk to amphipods, lobsters, shrimp, and mysids until diluted about a thousand times from the recommended treatment dose (up to four hours after release).

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J6

ERNST[1] W., F. PAGE[2], G. JULIEN[1], K. MACKAY[3], T. SUTHERLAND[4], C. GARRON[1]

DISPERSION OF SOLUTIONS USED TO TREAT SEA LICE ON SALMON IN NET PEN ENCLOSURES

Pesticides are often used to control sea lice (*Lepeophtheirus salmonis* and *Caligus elongatus*) infestations on farmed salmon (*Salmo salar*). Large quantities (up to 4000 m^3) of such pesticide solutions are released to the environment after treatments which typically last one hour. In order to determine the dispersive characteristics of pesticides such as azamethiphos and cypermethrin, sampling was conducted using a flow through fluorometer at various times after release of a treatment solution to which Rhodamine dye was added.

After six simulated treatments, dye plumes could be tracked for ½ hr to 5.5 hr. The maximum measured areas of the plumes were up to 1 km^2, and the time to reach approximately 1/1000 the treatment dose, a concentration shown to be toxic to non-target invertebrates, was up to four hours post release.

The results indicate a significant risk to the marine environment when highly toxic pesticides such as cypermethrin are used.

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[3] Matec Limited, Halifax, NS
[4] Canadian Wildlife Service, BC

J7

HAMOUTENE[1] D., C. ANDREWS[2], A. RAHIMTULA[1], J.F. PAYNE[2]

DEVELOPMENT OF A BIOCHEMICAL ASSAY FOR ASSESSING TOXICITY TO INVERTEBRATE AND FISH SPERM

In the broadest ecological sense, reproductive toxicity is one of the most important types of toxicity, since any stress that continually interferes with the process of reproduction could have long-term consequences. Effects on sperm are an important component of reproductive toxicity and there is value in developing a short-term toxicity assay for assessing potential effects on sperm function. The reduction of resazurin by cellular dehydrogenases is an excellent indicator of overall metabolic function and the resazurin assay has been used in a limited manner to evaluate sperm quality in humans and domestic animals. This is normally carried out through detection of color change of the dye by visual inspection or colorimetry. Since the product formed (resorufin) upon the reduction of resazurin is highly fluorescent, the method could be applicable to aquatic organisms as a rapid and sensitive assay for sperm toxicity. This was confirmed in studies with sea urchins. Tributyl tin was observed to depress enzyme activity in sperm briefly exposed to chemical levels in the parts per billion range. Mining effluents are coming under greater scrutiny in Canada and complex mixtures of iron-ore leachates which have generally been considered to be non-toxic under CEPA and Canadian Water Guidelines, have also been observed to depress enzyme activity in sperm. These and other results will be presented. The results indicate that the resazurin assay has potential for assessing risks of toxic chemicals on different types of invertebrate and fish sperm as well as screening for toxic effects through use of a prototype sperm such as from sea urchins which are widely available. (Supported in part by the Toxic Chemicals Program, Department of Fisheries and Oceans).

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J8

JONCZYK[1] E., G. GILRON[2], B. ZAJDLIK[3]

COMPARISON OF SEA URCHIN FERTILIZATION TEST RESULTS USING NATURAL AND SYNTHETIC MARINE WATER

The sea urchin fertilization test is commonly included as part of a battery of tests using marine species for routine monitoring, investigative and/or regulatory testing of effluents and pore water. The existing Canadian and U.S. EPA test procedures using sea urchin (and sand dollar) gametes allow for the use of either natural or synthetic marine water for culturing/holding test organisms and for full-scale testing. At present, the hypothesis is that synthetic marine water prepared by dissolving commercially-available dry salts in demonised water will not confound test data. The testing procedures simply state that there are no data available for evaluation of this hypothesis at this time, and that the use of artificial sea salts should be considered 'provisional'. The use of artificial seawater has yielded control fertilization rates equal to those of natural seawater (U.S. EPA, 1995). It is unknown whether natural and synthetic seawater used as control/dilution water in the sea urchin fertilization test will produce similar results. We will present the results of a series of parallel tests using a reference toxicant (i.e., copper sulphate) and several industrial effluents. Preliminary data obtained from conducting reference toxicant tests show higher variability and greater sensitivity when natural seawater is used as control/dilution water in comparison to the artificial seawater. Moreover, preliminary results obtained from testing industrial effluents suggest that natural and synthetic seawater yield similar results. Conclusions and recommendations based on a statistical evaluation of the data will also be presented.

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J9

SALAZAR[1] M.H. , S.M. SALAZAR[2]

CAMPESTROL IN CAGED MUSSELS AS A TRACER OF PULP AND PAPER MILL EFFLUENTS

In 1997, a caged mussel pilot study was conducted at a sulphite mill on Vancouver Island, BC, to determine the utility of this field monitoring approach. The exposure-dose-response triad design was used: external exposure from the surrounding media (water and sediment); internal dose of chemicals in mussel tissues (bioaccumulation); and the mussel growth response (effects). The results of the exposure and response assessments, presented at the 1997 Aquatic Toxicity Workshop, showed decreasing concentrations of spent sulphite liquor and dissolved oxygen and increasing growth rates with distance from the outfall. Plant sterols measured in mussel tissues were used to estimate dose. The best relationship between plant sterols and distance from the effluent diffuser was for campestrol. Not only was there a gradient of decreasing concentrations of campestrol with distance from the diffuser, but there was also a statistically significant relationship between the decreasing concentration campestrol in mussel tissues and the in.reases mussel growth rates. Although these relationships do not establish causality, it is encouraging to find concordance between all three legs of the triad and suggests that campestrol might be useful as a tracer for pulp and paper mill effluents.

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K1

THOMAS[1] M., D. PETIT[1], L. LAMBERTS[1]

LES SÉDIMENTS D'EAU DOUCE TÉMOINS EN BELGIQUE DE L'INCORPORATION DES MÉTAUX LOURDS : DISTINCTION DES APPORTS ANTHROPIQUE ET DÉTRITIQUE

Les sédiments non perturbés permettent l'échantillonnage d'une carotte de un mètre de long dont les couches les plus profondes sont vieilles de 100 ans. Deux sites ont pu être étudiés en Belgique: l'un, bras non navigable de la Meuse, a une masse sédimentaire résultant de la décantation des matières en suspension charriées par le fleuve, l'autre, étang situé dans le sud du massif forestier ardennais, est caractérisé par des apports atmosphériques prédominants. Un troisième site, lacustre, en bordure d'une zone urbaine et industrielle a été comparé.

La détermination du profil de désintégration du plomb-210 permet de vérifier le caractère préservé de la sédimentation et d'établir une échelle temps de un siècle superposable aux profondeurs de sédimentation; des horizons particuliers la confirment. Les teneurs-traces en différents métaux ont été mesurées.

La détermination des métaux lourds permet de préciser les apports naturels des apports anthropiques. Ceux-ci se révèlent essentiellement d'origine industrielle et diminuent (Zn, Cd, As...) dans les couches les plus récentes ; l'apport en Pb fait exception: il ne présente pas d'atténuation récente! La mesure des rapports isotopiques Pb montre cependant qu'à un apport décroissant en Pb d'origine industrielle se superpose un apport en Pb croissant d'origine pollution automobile!

Les apports d'origines différentes sont confirmés par l'utilisation de réactifs sélectifs permettant des attaques fractionnées.

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K2

HEDLEY[1] K., B. MICHELUTTI[2]

ENVIRONMENTAL EFFECT MONITORING FOR THE METAL MINING INDUSTRY

Since the completion of the Assessment of the Aquatic Effects of Mining in Canada (AQUAMIN) in 1996, Environment Canada has been working with stakeholders to implement the package of consensus AQUAMIN recommendations. One key area that AQUAMIN made specific recommendations on was the design of a national environmental effects monitoring (EEM) program for the metal mining industry. A multi-stakeholder working group and numerous technical sub-groups have been established and are currently developing an EEM program for inclusion in the Metal Mining Liquid Effluent regulations currently being amended as per the AQUAMIN recommendations. The presentation will include a general description of the EEM program to date currently under discussion by the EEM Working Group, the relationship of the EEM program to the amended regulation and a brief description of the differences between the existing pulp and paper and planned metal mining EEM programs.

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K3

PAINE[1] M.

DERIVATION AND APPLICATION OF WATER QUALITY CRITERIA : JUNK SCIENCE OR VOODOO CULT?

Water (and sediment) quality criteria (WQC) can be effective screening tools for environmental management and qualitative risk assessment. However, some of the current practices used to derive and apply WQC in Canada are not scientifically defensible, and could easily be improved. WQC are often based on effects thresholds derived from hypothesis testing, such as Lowest Observed Effects Concentrations (LOEC). Quantiles such as LC*p*, EC*p* or IC*p* are more suitable for derivation of WQC because effect sizes are standardized. WQC should not be based on a single extreme (e.g., the minimum) from a distribution of LOEC or quantiles from the literature. These extreme values are often suspect, and may be potential outliers. Using a single value from a literature review is also a poor use of data. The lower 10th or even 20th percentile from the distribution of literature values will provide a more robust, but still protective or "safe" level. Extrapolations from acute to chronic, species to species, and compound to compound can be used to expand sparse databases. WQC are used as standards for assessing environmental concentrations. These environmental concentrations should be means, based on multiple observations collected over time intervals comparable to those used in acute and chronic toxicity tests. The effects thresholds and quantiles used to derive WQC are based on average concentrations, not single instantaneous values, extreme (e.g., 90th or 95th) percentiles, or maxima.

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K4

ROE[1] S.L., R.A. KENT[1], P.Y. CAUX[1]

TISSUE RESIDUE GUIDELINES FOR THE PROTECTION OF WILDLIFE CONSUMERS OF AQUATIC LIFE : DIOXIN-LIKE COMPOUNDS

Mixtures have long been identified as a challenge in guideline development. A first step towards solving this problem is to develop guidelines based groups of compounds which share a similar characteristics. An ideal candidate group for this novel approach are dioxins and dioxin-like compounds (*e.g.*, some PCBs). These chemicals are known to act on the *Ah*-receptor, a protein conserved across most organisms, including mammals, birds and fish. The relative toxicities of the various chemicals have been shown to be dependent on the degree to which they induce *Ah*-receptor activity. Armed with this information, a complex mixture containing varying amounts of dioxin-like compounds may be expressed in relative terms as dioxin toxic equivalents (TEQs). Comparisons can now be made among the biological effects observed in wildlife populations exposed to different concentrations of dioxin-like compounds. Biological effects of PCBs and dioxins observed in field and laboratory studies were compiled and assessed for mammalian and avian species. The lowest-observed-adverse effect-levels (LOAELs) on a TEQ basis were used to generate reference concentrations for various wildlife species resident in Canada. The lowest RC was chosen as the TRG. Owing to the intimate connection between PCBs and dioxins/furans, TRGs for these two groups of contaminants must not be considered in isolation.

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K5

GAUDET[1] C., S. OUELLET[1], G.E. NASON[2], H.E. SIMMONS[1], L.S. JUERGENSEN[1], T. SCHNEIDER[3]

CANADIAN SOIL QUALITY GUIDELINES FOR PETROLEUM HYDROCARBONS

In 1997, The Canadian Council of Ministers of the Environment (CCME) requested development of soil quality guidelines for petroleum hydrocarbons to lend national consistency to the assessment and remediation of petroleum contaminated soils in Canada. Based on the results of a multi-stakeholder workshop held in Canada, the CCME recommended a tiered approach to the development of soil quality guidelines for protection of the environment and human health, consistent with the Canadian Framework for Assessment and Remediation of Contaminated Sites: i.e., Tier 1 generic guidelines, Tier 2 site-specific objectives, and Tier 3 risk assessment. Options for Tier 1 guidelines are based on elements of the existing British Columbia Environment (BCE) and Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) approaches, and define petroleum hydrocarbons in terms of specified carbon fractions. Based on an initial evaluation, the CCME proposes that Tier 1 be based on 3 to 4 windows or carbon ranges representing various molecular weights (volatile, light extractable, heavy extractable, and possibly higher MW in the $>C_{32}$ to C_{50} range). At the Tier 1 level, it is also recommended that 3 (or 4) guidelines be derived distinct carbon boiling point ranges with no separation of the alkanes/cycloalkanes and aromatics/alkenes. Currently, three multi-stakeholder Technical Advisory Groups (TAGs) have been set up to advise the CCME on precise delimiters for the recommended carbon ranges, the need for a fourth heavier fraction ($>C_{32}$ up to C_{50}), surrogates for each boiling point range fraction; and plausible Tier 2 and 3 approaches.

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[3] Environmental Consultant, Ottawa, ON

K6

CHÉNIER[1] R.

IDENTIFICATION ET GESTION DES SUBSTANCES PERSISTANTES ET BIOACCUMULABLES CIBLÉES POUR L'ÉLIMINATION VIRTUELLE DE L'ENVIRONNEMENT

Malgré les réductions des rejets de substances persistantes accumulables dans l'environnement, celles-ci se retrouvent encore dans l'environnement canadien. Aux termes de la Politique de gestion des substances toxiques, 12 substances ont été confirmées en juillet 1998 comme étant ciblées pour l'élimination virtuelle. Cette présentation fait état des initiatives durant la dernière année relatives à la gestion de ces substances. Les actions pour éliminer ces substances doivent inclure des initiatives au pays et à l'échelle internationale. En janvier 1998, le Conseil canadien des ministres de l'environnement (CCME) a adopté une politique de gestion qui prévoit la coopération, notamment en ce qui a trait à l'élimination de ces substances. Des initiatives se poursuivent, notamment à travers des groupes tel le Groupe de travail fédéral - provincial sur les dioxines et furannes. Des actions internationales importantes ont également eu lieu dans le contexte de la Commission économique européenne et du Programme de l'environnement de l'ONU.

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L1

OAKES[1] K.D., G.J. VAN DER KRAAK[1]

EFFECTS OF BLEACHED KRAFT MILL EFFLUENT (BKME) EXPOSURE ON HEPATIC LIPID PEROXIDATION IN A FERAL WHITE SUCKER (*CATOSTOMUS COMMERSONI*) POPULATION

Fish exposed to bleached kraft mill effluent consistently exhibit reduced circulating levels of reproductive steroid hormones, reduced gonadal growth, and an increased age to sexual maturation. There is increasing evidence that some industrial pollutants discharged into aquatic environments have the capacity to increase lipid peroxidation in aquatic organisms by virtue of their promotion of free radical production. Lipid peroxidation can exert significant organismal responses, especially at the cellular level. Peroxidation impairs biological membrane function by decreasing fluidity, increasing non-specific ion permeability, and through the inactivation of membrane bound receptors and enzymes. In addition to altered membrane function, the reaction products can themselves exert cytotoxic effects. This study examined feral white sucker (*C. commersoni*) sampled from the Mattagami River in the Fall of 1997, 0.5-1 km below the pulp mill at Smooth Rock Falls (exposed), and 2-3.5 km upstream (reference). Exposed mature females exhibited significantly elevated levels of hepatic lipid peroxidation as measured by the 2-thiobarbituric acid assay (TBARS), while exposed males had a similar, though non-significant increase in hepatic TBARS. The physiological relevance of elevated lipid peroxidation, in relation to observed reproductive changes of fish exposed to BKME, remains unclear.

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L2

FRANK[1] M., M. MCMASTER[1], K. MUNKITTRICK[1], M.C. SAVOIE[2], C. WOOD[3]

EFFECTS OF SULPHITE AND BLEACHED KRAFT PULP AND PAPER MILL EFFLUENTS ON YELLOW PERCH AND JOHNNIE DARTERS

Following first cycle EEM results, two mills (one bleached kraft, one sulphite) along the Ottawa River displayed potential alterations in fish species captured downstream of their effluent discharges. A collaborative agreement between James Maclaren Industries/Noranda Forest Inc. and Environment Canada was formed to examine feral fish in these areas. The objectives of this study were to validate the findings of cycle 1, evaluate the installation of secondary treatment systems at these mills, and to assess the potential for use of forage fish species in the EEM program. Biological samples were retrieved from various sites along the Ottawa and Lièvre rivers. Yellow Perch (*Perca flavescens)* was the predominant large species caught and the Johnnie Darter (*Etheostoma nigrum* Rafinesque) was the most common forage fish. Length, weight and gonad and liver sizes were recorded for all fish. Blood, gonad, and liver samples were taken from Perch for steroid hormone, fecundity and MFO analysis respectively. Gonad tissue was removed from the Johnnie Darters for *in vitro* steroid hormone analysis. Initial results show significant differences in perch populations downstream of both mills. There are also significant differences between the perch populations downstream of the sulphite mill and downstream of the municipal sewage facility which is on the opposite side of the Lièvre river. Our results show that the Johnnie Darter has the potential to be a viable sentinel species.

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[2] James McLaren Industries, Masson, QC
[3] Noranda Technology Centre, Montreal, QC

L3

COAKLEY[1] J.D., P.V. HODSON[1], A.R.P. VAN HEININGEN[2], T. CROSS[1]

THE ROLE OF PULP BLEACHING IN MFO INDUCTION IN RAINBOW TROUT

Fully bleached kraft pulp mills produce effluents that cause induction of hepatic mixed function oxygenase enzymes (MFO) in rainbow trout. Using bioassays of MFO induction in trout, spent filtrates from pulp bleaching were assessed for their MFO induction potency. Filtrates were collected from kraft mills in Cornwall, Ontario and Smooth Rock Falls, Ontario to assess the potency of filtrates from hardwood and softwood bleaching, respectively. Mill-bleaching filtrates induced MFO activity at concentrations greater than 5.6% v/v filtrate, and filtrates from softwood pulp bleaching appeared more potent than filtrates from hardwood bleaching. In laboratory bench-scale bleaching experiments, pulp from a kraft mill in Miramichi, New Brunswick was bleached via an industry-standard 5-stage chlorine dioxide bleaching sequence. The filtrates were collected and used in fish bioassays to assess MFO-inducing potency. Potency of laboratory filtrates to induce MFO activity varied depending on the bleaching stage, with the first alkaline extraction stage having the highest potency.

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[2] University of New Brunswick, NB

L4

DUBÉ[1] M.G., J.M. CULP[2], W.R. PARKER[3], S. COURTENAY[4], J.A. SMITH[1]

THE UTILITY OF MESOCOSMS/FIELD BIOASSAYS AS AN ALTERNATIVE TO THE CANADIAN ENVIRONMENTAL EFFECTS MONITORING (EEM) PROGRAM ADULT FISH SURVEY

In July, 1997, a pilot study was conducted at Irving Paper in Saint-John, New Brunswick to evaluate the technical suitability and cost-effectiveness of using mesocosms/field bioassays as an alternative to the standard pulp and paper EEM adult fish survey. The pilot study was necessitated by the need for alternate monitoring approaches in marine and estuarine receiving environments with complex effluent dispersion patterns, confounding effluent discharges, and a lack of abundant, non-mobile sentinel species. Results showed that fish (*Fundulus heteroclitus*; mummichogs) can be maintained effectively in the system for extended periods, and the system effectively mimics the receiving environment with respect to physical and chemical parameters. The mesocosm provided controlled exposure, allowed for the assessment of a variety of biological endpoints (growth, condition, liver weight, gonad weight, mixed function oxygenase induction, and plasma and *in vitro* steroid hormone production), and the project confirmed the utility of resin acids as a tracer for secondary treated effluents. In addition, the study provided previously unattainable information on effluent-related effects for a mill discharging to an extremely complicated receiving environment. However, this mesocosm/field bioassay system requires further pilot work before it can be accepted or rejected as an alternative to the EEM adult fish survey. A preliminary evaluation of the tool is presented and improvements to the design of the system are discussed.

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L5

PARKER[1] R., M. HAGEN[2], J. BOYD[2] , C. LANGLOIS[3]

ENVIRONMENTAL EFFECTS MONITORING AT PULP AND PAPER MILLS DISCHARGING TO THE MARINE ENVIRONMENT

In 1992, Canada passed amendments to the Pulp and Paper Effluent Regulations (PPER) which required every mill to conduct an environmental effects monitoring (EEM) program. The objective of the EEM was to determine if the fish, fish habitat and the utilization of the fisheries resource were being adequately protected by the requirements of the regulations. The EEM study components included an adult fish survey, an invertebrate community survey, sub-lethal toxicity testing on mill effluents, measurements for chlorinated dioxins and furans in fish tissue for mills using chlorine and a fish tainting study if there were public concerns about this issue. The first reports on the results of EEM studies from 134 mills in Canada were submitted in April, 1996. Of those mills, 32 discharged effluent to the marine environment.

The EEM program for marine mills faced many technical and scientific challenges due to the presence of tides, salinity gradients, complex effluent mixing zones and the diversity of the biological communities. Despite all of these issues, the first cycle EEM program for these marine mills also produced some interesting and useful results. This paper will review the results of the adult fish survey, the benthic invertebrate surveys, the effluent sub-lethal toxicity tests and the measurements for chlorinated dioxin and furans for the 32 marine mills in Canada. Patterns and trends in these results will be identified and the technical issues that were encountered will be discussed.

The second cycle of EEM studies at pulp mills is currently underway within reports due in April, 2000. The changes that have been made to the program to deal with the issues and challenges in the marine environment will be discussed.

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L6

LANGLOIS[1] C., D. ST-LAURENT[1] , N. DUBUC[2]

ÉTUDES DE SUIVI DES EFFETS SUR L'ENVIRONNEMENT (ESEE) DES FABRIQUES DE PÂTES ET PAPIERS DU QUÉBEC: SYNTHÈSE DES RÉSULTATS DU CYCLE 1 EN EAUX DOUCES

En vertu du règlement fédéral sur les effluents de pâtes et papiers, 42 fabriques rejetant leurs effluents en eaux douces ont procédé à une Étude de Suivi des Effets sur l'Environnement (ESEE) entre 1994 et 1996. Les résultats obtenus montrent que, après la mise en opération du traitement secondaire, on observe une baisse importante de la toxicité sous-létale des effluents pour les trois organismes testés, à savoir l'algue *Selenastrum capricornutum*, le cladocère *Ceriodaphnia dubia* et le mené Tête-de-boule (*Pimephales pomelas*). Chez les communautés d'invertébrés benthiques recensées dans le milieu récepteur, l'abondance et la diversité sont souvent significativement différentes entre les zones d'exposition et les zones de référence, ce qui s'explique cependant parfois aussi par des facteurs confondants autres que l'effluent de l'usine. Bien que peu d'usines ont satisfait entièrement aux exigences pour le nombre minimum de captures de poissons, des différences entre les populations des zones d'exposition et de référence ont été observées, surtout pour l'indice gonado-somatique, la fécondité et le rapport hépatosomatique. Pour huit papetières utilisant ou ayant utilisé du chlore pour le blanchimen , les concentrations de dioxines et furannes mesurées dans les muscles de poissons sportifs confirment une diminution sensible des teneurs dans le poisson au cours des 10 dernières années.

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M1

NIPPER[1] M., S. CARR[2], J. BIEDENBACH[2], R. HOOTEN[2], S. SAEPOFF[3], K. MILLER[4]

GENERATING A MARINE TOXICITY DATABASE FOR ORDNANCE COMPOUNDS

Several sites in the vicinity of Naval facilities are contaminated with ordnance compounds, e.g., 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, tetryl, picric acid, and royal demolition explosive. Marine toxicity data for these compounds are very scarce, and to our knowledge there are no marine Water Quality Criteria (WQC) for any of them, in the USA. A toxicity database was generated to help assess the potential effects of these chemicals in marine environments. Lethal and sublethal toxicity tests in aqueous solutions were conducted, including: zoospore germination and growth of the macro-alga *Ulva fasciata*, embryo development of the crab *Callinectes sapidus*, survival and hatching success of red drum (*Sciaenops ocellatus*), the sea urchin (*Arbacia punctulata)* fertilization and embryological development tests, and the life-cycle test with the polychaete *Dinophilus gyrociliatus*. Picric acid, a primary degradation product of tetryl and one of the most abundant nitro-aromatic chemicals in sediments around some naval facilities, was among the least toxic, and 1,3,5-TNB, usually less abundant, was one of the most toxic, with EC_{50} values >100 and <1 ppm, respectively (nominal concentrations). The information generated from these studies will be used to support the development of marine water quality criteria for use in a regulatory framework on a national level.

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M2

CARR[1] S., M. NIPPER[2], J. BIEDENBACH[1], R. HOOTEN[1], S. SAEPOFF[3], K. MILLER[4]

TOXICITY IDENTIFICATION EVALUATION (TIE) STUDIES AT SITES SUSPECTED OF ORDNANCE CONTAMINATION

As the result of past storage, improper disposal and use of explosives, the sediments at a number of marine and estuarine sites have been shown to have measurable concentrations of a variety of ordnance compounds, e.g., 1,3,5-trinitrobenzene, 1,3-dinitrobenzene, 2,4,6-trinitrotoluene, 2,4-dinitrotoluene, 2,6-dinitrotoluene, tetryl, picric acid, and royal demolition explosive (RDX). In order to determine whether these ordnance compounds were responsible for any observed toxicity, a preliminary survey was conducted at two sites in Puget Sound suspected of ordnance contamination. Sediment samples were collected at twenty-five stations from each of the two sites and porewater fertilization and embryological development tests were conducted with the sea urchin *Arbacia punctulata*.

Thirty-four and 94% of the samples from the 50 stations were toxic in the 100% pore water samples for the fertilization and embryological development tests, respectively. The most toxic samples were selected for comprehensive chemical analyses. Based on the results of the chemical analyses three stations were selected for the comprehensive TIEs which focused on the stations with the highest concentrations of ordnance compounds. The results of these TIE investigations will be presented.

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M3

ST-LAURENT[1] D., C. CÔTÉ[2] , M. PROVENCHER[1]

ÉVALUATION DE LA QUALITÉ DES SÉDIMENTS À UN SITE DE DÉPÔT DE MATÉRIAUX DE DRAGAGE AU MOYEN D'UNE APPROCHE EN TRIADE

Afin de s'assurer que les activités d'immersion de matières draguées n'entraînent pas d'effets dommageables pour l'environnement, un programme de suivi environnemental a été réalisé en 1997 à un site de dépôt (dépôt D) aux Îles-de-la-Madeleine. Le dépôt D a reçu environ 1 400 000 m^3 de sédiments dragués non contaminés entre 1980 et 1997. Le suivi physico-chimique consistait à mesurer dans les sédiments un ensemble de variables physiques et chimiques. Quant aux suivis toxicologique et benthique, ceux-ci reposaient sur des tests de toxicité réalisés en laboratoire (inhibition de la fécondation chez l'oursin de mer *Lytechinus pictus*, survie de l'amphipode *Rhepoxinius abronius*, Microtox™ sur les phases solide et liquide), une analyse de la communauté d'invertébrés benthiques, et la mesure de l'activité exoenzymatique bactérienne *in situ*. Aucun contaminant préoccupant n'a été mesuré en concentration supérieure aux normes et critères en vigueur, aucun essai de toxicité, mis à part celui sur l'oursin de mer, n'a démontré une toxicité pour les organismes aquatiques utilisés et la structure de la communauté benthique était sensiblement la même dans les zones de dépôt et de référence. Les seules différences observées à ce niveau ont été attribuées à la nature du substrat et possiblement à la profondeur des stations. L'essai de fertilization chez l'oursin et la mesure de l'activité exoenzymatique *in situ* ont démontré une forte sensibilité à des substances d'origine dite naturelle telles que l'azote ammoniacal, les sulfures, le carbone organique total et les particules fines. Ces résultats et leur interprétation seront discutés.

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M4

GILRON[1] G. , E. JONCZYK[2], R.S. CARR[3] , P. MCKEE[2]

THE USE AND SELECTION OF MARINE TOXICITY TESTS FOR THE EVALUATION OF CONTAMINATED SEDIMENT

The Sediment Triad is a common approach used in the bioassessment of contaminated sediments in the marine environment. A crucial component of the triad approach is the use of toxicity tests, which are used to generate data on the biological effects of sediments (and associated pore water) on marine benthic biota. Some of the more common tests used are as follows: the Microtox™ solid-phase test, the Toxi-Chromotest™, the echinoid fertilization and embryological development tests, the amphipod survival test, the polychaete growth and survival test, and the clam toxicity and bioaccumulation test. There are also a number of less common, more specialized tests that have been used, which have proven effective. The toxicity tests have usually been applied in the form of a test "battery", in order to encompass effects on different trophic components. Each of the tests is chosen in order to obtain different information on the biological quality of the sediments; for example, the echinoid test uses pore water in a short-term exposure which provides an estimate of potential chronic effects, whereas the polychaete test involves exposing juveniles to whole sediments in a long-term chronic test design which evaluates effects on growth and survival. This presentation will review toxicity test data obtained from numerous sediment impact assessments conducted in Canada and the United States, in addition to recent work presented in the literature. We further qualitatively evaluate the various toxicity tests used in sediment bioassessments, their relative sensitivity to various contaminants, and their overall utility in the Sediment Triad process. Finally, we recommend a strategy for the selection of marine toxicity tests in the evaluation of contaminated sediment bioassessments.

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M5

ENGEL[1] D.W., D.W. EVANS[1]

SEDIMENT CONTAMINANT MONITORING DATA FROM THE COASTAL GULF OF MEXICO AND ITS USEFULNESS IN HAZARD ASSESSMENT

Evaluations of distributions of sediment associated contaminants and their potential effects on fishery organisms in the Gulf of Mexico have been completed. Existing data bases (EPA/EMAP, NOAA/NS&T, State of Florida, and EPA/STORET) were employed covering 15 years of sample collection. Data on selected persistent contaminants in sediment were collated and frequency distributions developed in four regions: South Florida; North Florida, Alabama, and Mississippi; Mississippi River Delta; and Western Louisiana and Texas. To evaluate the relative toxicity of the sediments, the ER-L and ER-M guidelines for a suite of metals and organics were overlaid on the observed frequency distributions. Few sites in the Gulf exceeded the ER-M for metals and mercury most frequently exceeded the ER-M at such sites. Among organics, total DDT and PCB's had the highest number of sites exceeding the ER-M, with such sites distributed throughout the Gulf. Tissue contaminant concentrations (EPA/EMAP and NOAA/NS&T) and sediment bioassay data (EPA/EMAP) have been compared with sediment contaminant concentrations. Comparisons show both negative and positive correlation between tissue contaminant concentrations in fish and sediment concentrations. While suggested patterns of contamination exist, the difficulty in using these monitoring data for hazard or risk assessment is that there are not clear assessment and measurement endpoints that can be identified.

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M6

HELLOU[1]J., J. LEONARD[1], C. ANTSEY[1], J. MEADE[2], J. FARRINGTON[3], S. PAPIERNIK[3], L. EGLINTON[3], J. WHELAN[3] , A. GRONLUND[1]

COMPARATIVE FATE OF POLYCYCLIC AROMATIC COMPOUNDS (PACS): PRESENCE, BIODEGRADATION, BIOACCUMULATION AND BIOELIMINATION

The presence of tricyclic heteroaromatic compounds, containing N, S and O, namely carbazole, dibenzothiophene and dibenzofuran was investigated relative to that of the polycyclic aromatic hydrocarbon (PAH) counterpart, fluorene. The abundance of the parental PACs and alkylated derivatives was determined in a small number of environmental sources and sinks of contaminants, including crude oil, coal and harbour sediments. The persistence vs biodegradation of these low molecular weight PACs was investigated at 4 and 25°C using bacterial consortia collected from three marine beaches. Biodegradation was followed by measuring the disappearance of the starting material and by investigating the presence of oxidized derivatives in samples with differing background environmental histories. Differing biodegradation rates were observed between compounds and sediment location. The fate of fluorene, dibenzothiophene, carbazole and dibenzofuran was determined in an abundant lower link of the food chain, i.e. amphipods exposed to spiked sediments. This preliminary study corroborated the important role of amphipods in transporting contaminants in the food chain, since seabirds, lobsters and various finfish species prey on these small crustaceans. The long-term dietary fate of the four PACs was also investigated in tissues of finfish exposed to spiked food pellets. Analyses targeted muscle, liver, fatty tissue, blood, internal organs, as well as bile and faeces. Bioaccumulation results were examined on a per gram and whole organ basis. This approach aimed to compare the storage ability of a tissue over time, under chronic type exposure conditions and the use of tissues relative concentration ratios as markers of exposure to contaminants.

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N1

CROISETIÈRE[1] L., L. HARE[2], G. VAILLANCOURT[3]

L'UTILISATION DES MOUSSES AQUATIQUES POUR LE SUIVI DU CADMIUM EN MILIEU AQUATIQUE : INFLUENCE DE DIFFÉRENTS PARAMÈTRES SUR L'ACCUMULATION

Les mousses aquatiques sont utilisées depuis déjà plusieurs années comme bioindicateur de micropollution métallique en Europe. Au Québec, leur utilisation a débuté il y a quelques années et les résultats obtenus sont très prometteurs. Leur pouvoir exceptionnel de bioaccumulation permet le suivi de métaux à l'état de trace et l'établissement de patrons de dispersion de ces polluants. Nous avons réalisé des expositions au cadmium en laboratoire qui confirment, par le biais des facteurs de bioconcentration très élevés chez la mousse aquatique *Fontinalis dalecarlica* (environ 85 000), le pouvoir impressionnant de ce groupe d'organismes pour concentrer des métaux traces. Par contre, des paramètres étant reconnus pour exercer une influence importante sur l'accumulation, comme la vitesse de courant, ne semblent pas être aussi importants que prévu. Nos résultats révèlent que la vitesse de courant influence peu l'accumulation du Cd chez *F. dalecarlica*, même à des vitesses aussi élevées que 0.7 $m^3.s^{-1}$. Nous avons aussi réalisé des mesures sur le terrain qui valident nos observations en laboratoire.

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N2

COSSA[1] D.

THE BIOAVAILABLE MERCURY SPECIES IN AQUATIC ENVIRONMENTS : EXAMPLES FROM *IN SITU* MEASUREMENTS

In natural waters mercury occurs in several physical and chemical forms. Dissolved mercury is distributed among Hg°, inorganic and organic Hg(II), including the toxic methylated species. It is now currently admitted that the major species changes (methylation/demethylation, oxidation/reduction) depend from photochemical and biological reactions and, that, the inorganic Hg(II) pool constitutes the biologically active substratum. On the other hand, thermodynamic calculations predict that the divalent mercury is partially present in oxic water as uncharged species : $Hg(OH)_2$ and CH_3HgOH in freshwater or $HgCl_2$ and CH_3HgCl in estuarine waters. In anoxic waters Hg(II) is bounded to sulfides or thiols. In the particulate matter mercury is associated with humic compounds and oxyhydroxides or sulfides. This pool is though to be in equilibrium with ionic dissolved species and constitutes a large reservoir for potential mercury mobilisation leading to the formation of bioavailable species. Current paradigms suggest that the most available species for the primary producers are the small neutral species which readily enter the cell by passive diffusion, and that the bioaccumulation results of the strong affinity of methylated species for proteins and the solubility of CH_3HgCl in the lipid tissues of predatory animals. We present the results of speciation studies performed in various rivers, lakes, estuaries and coastal zones from boreal to tropical environments, which allow to identify the distributions of biological active mercury species in the water and sediments.

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N3

FORTIN[1] C., P.G.C. CAMPBELL[1]

INTERACTIONS OF SILVER WITH A UNICELLULAR ALGA: TRANSPORT MECHANISMS THROUGH THE CELL WALL AND THE PLASMA MEMBRANE IN RELATION TO CHEMICAL SPECIATION

Many of the apparent exceptions to the Free-Ion Model (FIM) of metal toxicity involve either ligands that are assimilable on their own (so-called "accidental" metal transport - e.g., *Water Res.* 32: 419-429 (1998)), or ligands that form neutral lipophilic metal complexes (e.g., *Environ.Sci.Technol.* 28: 1781-90 (1994)). In the present project, we are attempting (i) to determine whether enhanced silver uptake may occur in the presence of chloride and (ii) to elucidate the mechanism(s) responsible for this behavior. We have chosen a unicellular alga, *Chlamydomonas reinhardtii*, as our test organism. This species is available in strains with / without the normal algal cell wall, allowing us to quantify the role of the cell wall in silver-algae interactions. Short-term (≤15 min) silver uptake is determined using ^{110m}Ag as a radio-tracer in defined inorganic media, with differentiation between adsorbed and intracellular metal. After first quantifying silver uptake rates in chloride-free media, we then increased the Ag and Cl concentrations together, in proportions calculated to give a constant free Ag^+ concentration. In such an experiment, the Free-Ion Model predicts that metal uptake should be constant, i.e. that the biological response should be insensitive to the increase in $AgCl_n$ species in solution. Contrary to this prediction, as $[Cl^-]$ was increased from 0 to 4 mM, at constant ionic strength and constant free $[Ag^+]$ (10 nM), the Ag uptake rate more than doubled. We suspect that this exception to the FIM is caused by "accidental" transport of silver chloride complexes and experiments to confirm this interpretation are currently underway.

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N4

ROSE-JANES[1] N., M. SCHWARTZ[1], R.C. PLAYLE[1]

PROTECTIVE EFFECTS OF DISSOLVED ORGANIC MATTER AGAINST THE PHYSIOLOGICAL AND TOXICOLOGICAL EFFECTS OF WATERBORNE SILVER ON FISH AND *HYALELLA*

Full scale physiological experiments were run to investigate the protective effects of dissolved organic matter (DOM) against silver uptake by cannulated fish in soft water. Rainbow trout (*Oncorhynchus mykiss*, 300 g) were exposed to 0.1 $\mu mol \cdot L^{-1}$ Ag (as $AgNO_3$) in soft water in the presence and absence of added DOM. Partial protective effects of DOM against Ag entry into the fish and against the respiratory and ionoregulatory effects of Ag in soft water were seen with the addition of 8 mg $C \cdot L^{-1}$ dissolved organic carbon (DOC) isolated from Luther Marsh, Ontario. Full protective effects were seen with the addition of 35 mg $C \cdot L^{-1}$ DOC (Aldrich), so that a decrease in plasma Cl from 118 $mmol \cdot L^{-1}$ to 98 $mmol \cdot L^{-1}$ in the absence of DOM was eliminated. The amount of Ag accumulating on the gills over 90 h was reduced by the addition of DOM from 8.9 $nmol\ Ag \cdot g^{-1}$ wet gill tissue to 3.5 $nmol\ Ag \cdot g^{-1}$ wet gill tissue. The amount of Ag entering the plasma of the fish was also reduced by the Aldrich DOM, from about 1.6 $\mu mol.L^{-1}$ Ag to 1.0 $\mu mol \cdot L^{-1}$ Ag. Silver accumulation by *Hyalella* was studied at ~0.15 µM Ag concentrations, with the objective of determining differing protective effects of UV-B degraded DOM compared to non-degraded DOM.

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N5

VIGNEAULT[1] B., A. PERCOT[2], M. LAFLEUR[2], P.G.C. CAMPBELL[2]

INTERACTIONS OF HUMIC SUBSTANCES WITH MODEL BIOLOGICAL MEMBRANES AND PHYTOPLANKTON SURFACES

The interaction of aquatic humic and fulvic acids with model biological membranes (liposomes) has been studied. The use of humic and fulvic acid isolated from a single source, the Suwannee River, has permitted the direct comparison of the effects of the two acids. The leakage of the fluorescent probe sulphorhodamine B (SRB), trapped in 1-palmitoyl-2-oleoyl-phosphatidylcholine (POPC) vesicles was measured as the concentration of humic substances was increased. At environmentally relevant pH and humic substances concentrations, both humic and fulvic acids increase the leakage from the vesicles. The effect of humic acid is stronger than for fulvic acid. The leakage is more important at pH 5.8 than 7.6 for the humic acid and is similar at the two pH for the fulvic acid. The introduction of a negatively charged phospholipid, 1-palmitoyl-2-oleoyl-phosphatidylglycerol (POPG), in POPC liposomes reduces the leakage induced by the humic substances. The behavior of the humic and fulvic acid with the vesicles corroborates adsorption and permeability measurements performed with phytoplankton. The modification of the biological membrane properties by the adsorption of humic substances is thought to have an impact on the uptake of hydrophobic compounds by passive diffusion.

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N6

VAN COILLIE[1] R.

BIOACCUMULATION ET DEVENIR DU MERCURE ET DU PLOMB DANS LES RHIZOMES DE SCIRPES DU FLEUVE SAINT-LAURENT

Les rhizomes de *Scirpus americanus* du Cap Tourmente du fleuve Saint-Laurent en aval de Québec renferment 0,8 mg Hg/kg et 34 mg Pb/kg. La bioaccumulation de ces deux métaux peut être très rapide chez ces scirpes car leurs valeurs précitées augmentent respectivement de 108 fois et 18 fois en 72 heures dans un milieu expérimental contenant 0,5 mg Hg/l ou 1,5 mg Pb/l. Lors de cette bioaccumulation, des granules de 50 à 200 nm se multiplient respectivement 30 fois et 6 fois dans les vaisseaux des rhizomes des scirpes. Des microanalyses microfluorescentes de rayons X par énergie et longueur d'onde dispersive en microscopie électronique à balayage ont permis de déceler que le mercure et le plomb bioaccumulés se retrouvent dans ces granules. Des microdiffractions en microscopie électronique à transmission ont également révélé que ces granules étaient principalement composées de métallothioprotéines cristallisées. Les scirpes du fleuve Saint-Laurent précipitent ainsi le mercure et le plomb aquatique dans les vaisseaux de leurs rhizones, ce qui rend ces deux métaux non biodisponibles pour les autres tissus de ces plantes. Toutefois, on ne connaît pas actuellement l'implication de cette capacité de bioaccumulation et précipitation des deux métaux dans les rhizomes de scirpes pour les oies blanches qui se nourrissent de ces rhizomes au Cap Tourmente durant une quinzaine de jours au printemps et à l'automne lors de leurs migrations.

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N7

NORWOOD[1] W., U. BORGMANN[1]

COMPARISON OF SOLID PHASE AND OVERLYING WATER AS SOURCES OF TOXICITY TO *HYALELLA AZTECA* IN LEAD-SPIKED SEDIMENTS

Experiments were conducted to determine if toxicity of lead to the amphipod *Hyalella azteca* in sediments was due to the solid phase or lead leached into the overlying water, and whether toxicity correlated accurately with metal accumulated in the body. Amphipods were exposed to a concentration series of lead-spiked sediments at two different water to sediment ratios (4:1 and 67:1). Animals were placed both directly in the sediment, and in cages with access to overlying water but not the sediment itself. Metal bioaccumulation and toxicity appeared to be controlled primarily by the aqueous phase. At the low water to sediment ratio, mortality to amphipods exposed in cages and to the solid phase sediment was equal, suggesting that toxicity was due to metal leached from the sediment, rather than the solid phase itself. Lead uptake was similar in all exposure types (cage and sediment exposed, low and high water to sediment ratios) at equivalent lead concentrations in the sediment. Lead concentration in the overlying water, however, was higher in the low water to sediment ratio treatments, and this corresponded with a higher DOC content. Lead bioavailability and toxicity were not, therefore, proportional to total lead in the water.

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N8

MUNGER[1] C., L. HARE[1], A. TESSIER[1]

IMPORTANCE OF FOOD FOR THE UPTAKE AND ELIMINATION OF CADMIUM BY THE AQUATIC INSECT *CHAOBORUS*

Metals can be accumulated by aquatic animals from the surrounding water or from the food that they eat. The relative contribution of water and food to animal metal content is poorly known, yet such information is important if we are to measure metal movements in food webs and to construct reliable models of metal accumulation in animals. We used a series of laboratory and field experiments to measure the importance of food as a Cd source to the phantom midge *Chaoborus*, as well as to study the influence of food-related variables on Cd bioaccumulation. The results of our laboratory experiments suggest that food (zooplankton) is the major Cd source for this predator. We verified our finding *in situ* by transferring *Chaoborus* from an uncontaminated lake to mesh mesocosms in a Cd-contaminated lake, where we determined that in nature these larvae also accumulate the majority of their Cd from food. In addition, we determined that Cd uptake from food was dependent on prey ingestion rate but independent of the type of prey consumed. Lastly, we measured Cd loss rates *in situ* as well as their dependence on predator feeding rate. Because our results suggest that food and food-related variables exert an important influence on animal Cd concentrations, we predict that differences in prey abundances among lakes could explain in part lake to lake variations in predator Cd concentrations.

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N9

ENGEL[1] D.W., D.W. EVANS[1]

FISH MERCURY BIOACCUMULATION : IT IS NOT ONLY WHAT YOU EAT, BUT HOW FAST YOU GROW!

Among both freshwater and marine piscivores the older and larger fish tend to have higher tissue concentrations of methyl mercury, but this may be modified through trophic position or rate of growth. We have examined the relationship between water chemistry, primary production, and tissue mercury concentrations in largemouth bass collected from water bodies in the southeastern U.S., and have demonstrated negative correlations between fish tissue methyl mercury concentrations and the chemistry and productivity of particular water bodies. In the marine environment where the water chemistry is relatively uniform and productivity is patchy, some pelagic piscivorous species have significantly elevated tissue concentrations of methyl mercury. Differences among species are not always positively related to the size of the fish even if they have similar food habits. Using fishery life history data we are developing models of methyl mercury bioaccumulation that use fish growth as an independent variable. We are validating the models with measurements of muscle methyl mercury concentrations in a variety of species. It appears possible to predict the specific species of fish that have the greatest potential for elevated tissue concentrations of methyl mercury through knowledge of trophic interactions and growth rates.

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O1

CHAPMAN[1] P.M.

SELENIUM FRESHWATER QUALITY DETERMINATIONS

Selenium is an essential element, but one for which dietary exposure is more important than water column exposure. It has been associated with severe aquatic environmental effects at relatively low water column concentrations. Sources of selenium include hard rock and coal mining, power generation, and agricultural irrigation. In freshwater lentic environments (reservoirs, lakes), deformities and mortalities have been observed in the F1 generation of fish and birds such that, in extreme cases, some species have virtually disappeared from the aquatic food web. Canadian water quality criteria are set at 1 µg/L, and U.S. EPA chronic criteria are set at 5 µg/L; discussions are currently ongoing as to whether the EPA value should be raised or lowered. Sediment and tissue quality values also exist, though they are not without controversy. A major issue is the apparent difference between lotic (streams, rivers) and lentic environments. Specifically, water column concentrations which can be ecologically devastating in some lentic environments appear to have no adverse effects on the exposed aquatic communities in lotic environments. The purposes of this presentation are to: (1) detail current issues related to Se in the aquatic environment; (2) recommend procedures which can be used to develop site-specific criteria for Se, including examples of how this has been done in two different U.S. states.

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O2

PRAIRIE[1] R., Y. LAVERGNE[2], C. CÔTÉ[3]

ÉVALUATION ÉCOTOXICOLOGIQUE DES SÉDIMENTS SITUÉS À PROXIMITÉ DE DEUX QUAIS À VOCATION INDUSTRIELLE

Des études antérieures menées près des structures portuaires de Mont-Louis et Sandy Beach ont révélé la présence de teneurs de contaminants pouvant dépasser les critères intérimaires de qualité des sédiments du St-Laurent (seuils d'effets néfastes). Dans le cadre de la cession des ports publics de Transports Canada, une entente tripartite est intervenue entre Noranda, inc., division Mines Gaspé (utilisateur des infrastructures), Transports Canada, et Travaux Publics (TPSGC), afin d'évaluer les effets de la présence de ces contaminants sur les organismes benthiques.

Ainsi, une évaluation de la qualité des sédiments présents autour de ces deux infrastructures portuaires a été effectuée à l'automne 1997. Elle avait pour objectif de caractériser le degré et l'étendue des zones affectées, non seulement au niveau chimique, mais également aux niveaux biologique (communauté benthique) et toxicologique (tests de toxicité utilisant l'amphipode marin et l'oursin de mer).

Les résultats obtenus ont confirmé que certains échantillons de sédiments analysés contiennent des concentrations élevées de certains contaminants. Cependant, les résultats ont montré, dans les deux cas (Mont-Louis et Sandy Beach), peu de différences au niveau des indicateurs biologiques et toxicologiques, et ce, malgré les différences importantes au niveau des concentrations tel que le cuivre.

L'intégration des résultats chimiques, biologiques et toxicologiques, incluant les données de l'extraction séquentielle de même que le rapport SEM-AVS, suggère que les concentrations mesurées de contaminants préoccupants n'expliquent pas à elles seules les réponses benthiques et toxicologiques mesurées. De plus, la qualité chimique des sédiments ne semble pas entraîner d'effets sévères sur la faune benthique.

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O3

BISPO[1] A., M. JAUZEIN

DÉVELOPPEMENT DE MÉTHODES DE CARACTÉRISATION DES DANGERS ET DES RISQUES ÉCOTOXIQUES LIES AUX DÉCHETS ET AUX SOLS CONTAMINÉS

La recherche a contribué à élaborer une procédure et à proposer des méthodes pour caractériser les dangers et les risques à court et à long terme, liés à la présence de composés toxiques, organiques et/ou métalliques dans les échantillons solides comme les sols et les déchets.

Les échantillons solides considérés sont des terres contaminées au laboratoire ou prélevés directement sur des sites industriels, et des déchets. Une batterie de tests biologiques combinant différents types d'effets (aigus, chronique et génotoxique) et différents niveaux trophiques (producteur, consommateur et décomposeur) a été réalisé en associant les tests sur *Vibrio fischeri, Pseudokirchneriella subcapitata, Daphnia magna* et *Vibrio fischeri* M169). Elle a été appliquée sur des extraits obtenus par lixiviation statique en faisant varier les solvants et les conditions de lixiviation, mais également par percolation dynamique en colonne. En parallèle, des essais de dégradation ont été conduits en suivant l'évolution de la toxicité et de la génotoxicité. Les résultats obtenus montrent que la caractérisation du danger toxique et génotoxique à court et long terme doit reposer sur l'utilisation d'une gamme de lixiviations statiques à l'eau et à d'autres solvants (comme le méthanol), couplée à une batterie de tests biologiques complémentaires. Elle peut ensuite être complétée par des essais de percolation et/ou de dégradation, afin d'acquérir des informations sur l'évolution de la toxicité.

Cette recherche a été financée par l'ADEME (Agence française pour l'Environnement).

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O4

ROBIDOUX[1] P.Y., J. HAWARI[1], S. THIBOUTOT[2], G. AMPLEMAN[2], G.I. SUNAHARA[1]

ECOTOXICOLOGICAL RISK ASSESSMENT OF A 2,4,6-TRINITROTOLUENE (TNT) CONTAMINATED SITE

2,4,6-Trinitrotoluene (TNT) is a munition chemical released to the environment from munition production and processing facilities, as well as through field use and disposal practices such as open areas. The extent of sites contaminated by this energetic compound is considered as a significant international problem. The high level of contamination at point source area and the recalcitrant properties of TNT have justified a number of studies. However, TNT and its metabolites are toxic and genotoxic at relatively low concentrations to a number of ecological receptors. A preliminary ecotoxicological risk assessment was conducted on a TNT-contaminated site. Toxicity data from the literature and recent laboratory data were compared to the exposure assessment to estimate the risk for ecological receptors. Assessment endpoints considered were direct effects on terrestrial (microorganisms, plants, invertebrates, mammals) and aquatic (algae, invertebrates, fish) organisms.

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05

CÔTÉ[1] C., R. PRAIRIE[2], N. BERMINGHAM[3], P. MIASEK[4]; M. ST-CYR[5], G. FERLAND[6]

ECOLOGICAL AND HUMAN HEALTH RISK ASSESSMENT OF A CONTAMINATED HARBOUR FACILITY IN MONTREAL

In order to assess the degree and extent of the contamination in the sediments in sector 103 of Montreal harbour area, an environmental risk assessment was carried out. This evaluation, managed by a consortium of partners representing both industrial and government interests, included three aspects: ecotoxicological, ecological and human health risk assessment . This presentation will focus on the later two aspects. The contamination in this section of the harbour is mainly the result of historical effluent discharges from petroleum and petro-chemical refineries, metal refining industries, in addition to municipal wastewater and urban runoff. Contaminants of concern include a variety of PAHs, oil and grease and several metals. In order to characterise the potential hazards, chemical and toxicological analyses of surface sediments and overlying water were conducted at the harbour site and reference areas. Water exchange rates, sediment re-suspension and transport were modelled to assess the potential risk at the site and in a downstream area. Receptors included waterfowl, fish and humans such as workers at the site, nearby residents (less than 1 km) and downstream recreational park users. Although the first tier of the risk assessment showed potential risks using conservative assumptions, the results of the study showed, using site-specific bio-concentration factors, that only PCBs and Hg concentrations could potentially lead to a marginal risk for human health associated with the consumption of a large quantity of resident fish.

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06

THÉBERGE[1] M.C.

L'ANALYSE DE RISQUES D'ACCIDENTS TECHNOLOGIQUES MAJEURS ET L'ÉVALUATION ENVIRONNEMENTALE DES PROJETS AU QUÉBEC

L'analyse de risques d'accidents technologiques majeurs a pour but la connaissance des événements indésirables associés à un projet ou à une installation existante, de la probabilité que surviennent ces événements et de l'ampleur de leurs effets. Elle se compose de cinq étapes principales : l'identification des dangers et des scénarios d'accidents permet de recueillir les informations nécessaires à l'analyse des risques (produits, équipements, activités, milieu environnant, accidents passés). L'estimation des conséquences permet de déterminer l'ampleur des effets néfastes (décès, blessures, dommages à l'environnement et aux structures) découlant d'un accident (incendie, explosion, nuage toxique). L'estimation des fréquences permet d'établir la probabilité qu'un accident se produise et engendre des effets néfastes.

L'estimation des risques permet d'intégrer les résultats de l'estimation des conséquences et des fréquences. L'évaluation des risques consiste à comparer les risques aux pratiques et préférences sociales afin d'en étudier l'acceptabilité.

Au Québec, les projets soumis à la *Procédure d'évaluation et d'examen des impacts sur l'environnement*, établie en vertu de la *Loi sur la qualité de l'environnement*, qui sont susceptibles d'être à l'origine d'accidents technologiques majeurs doivent faire l'objet d'une analyse de risques d'accidents technologiques. Cette analyse permet la considération des risques tôt dans le processus conceptuel d'un projet et vise à connaître les risques, à informer la population, à prévenir les accidents technologiques majeurs, à limiter les conséquences en cas d'accident et à planifier l'intervention d'urgence.

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O7

LORANGER[1] S., R. SCHETAGNE[2], M. PLANTE[3], L. HOUDE[4], Y. COURCHESNE[1]

ÉVALUATION DU RISQUE À LA SANTÉ RELIÉE À LA CONSOMMATION DE POISSONS PAR DES PÊCHEURS SPORTIFS TRAVAILLANT À LA BAIE JAMES

Afin d'évaluer le risque pour la santé relié à consommation de poissons par les pêcheurs sportifs, Hydro-Québec a entrepris un projet d'étude visant à estimer leur taux de consommation et leur exposition au méthylmercure (MeHg). Le premier volet de cette étude a été réalisé durant l'été 1997 et visait plus spécifiquement à évaluer le taux de consommation d'un groupe cible de 95 pêcheurs de la Baie James à l'aide d'un questionnaire et d'interviews. Ce volet a été complété par le prélèvement de cheveux de chacun des participants durant l'étude. Le second volet, qui fait l'objet de la présente communication, visait à calculer le taux de consommation des pêcheurs ainsi que la dose d'exposition individuelle à partir des informations contenues dans ce questionnaire et de celles recueillies lors des études de l'évolution des teneurs en mercure des poissons au complexe La Grande. La dose d'exposition au MeHg a été calculée pour chaque pêcheur et ce, par espèce et multispécifique, par jour et par mois ainsi que par site de pêche. Considérant la variabilité qui existe au niveau des paramètres utilisés pour les calculs (ex. : concentration de MeHg dans le poisson, taille des captures, nombre de repas effectué), une analyse d'incertitude a été réalisée. Le volet final de cette étude visera a intégrer ces doses à un modèle toxicocinétique à base physiologique afin d'estimer la concentration de mercure dans les cheveux pour une période donnée et à comparer ces estimations aux valeurs mesurées directement dans les cheveux des pêcheurs sportifs. Enfin, des modifications au questionnaire seront proposées afin d'améliorer la précision des estimations et de développer un outil d'évaluation et de suivi du MeHg précis et efficace.

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O8

PRICE[1] P.S., R.E. KEENAN[1], S.J. PAUWELS[2]

USING AN INTEGRATED MICROEXPOSURE EVENT AND TOXICOKINETIC MODEL TO EVALUATE IMPACTS OF DIOXINS ON ANGLER BODYBURDENS

The presence of polychlorinated dibenzo-p-dioxin (PCDD) and dibenzofuran (PCDF) congeners in fish downstream of pulp and paper mills has prompted some regulatory agencies to issue a number of fish consumption advisories. In many cases, the basis for these advisories is a screening-level deterministic risk calculation. Over the last 10 years, new modeling techniques have been developed to evaluate exposure to environmental contaminants. Two of these techniques are toxicokinetic models that relate body burdens to intake rates and probabilistic models that characterize the range of intake across individuals. We developed the Microexposure Event analysis as a refined method of probabilistic exposure assessment that incorporates a number of demographic and temporal changes in the various exposure parameters to properly consider variation in fish concentrations, cooking practices, and fish species. In this paper, we linked a Microexposure model of exposures to PCDDs and PCDFs from the consumption of fish to a toxicokinetic model. Using the combined models we estimated the hypothetical distribution of PCDD and PCDF concentrations in the blood of anglers who consume freshwater fish harvested from rivers downstream of pulp and paper mills in Maine and in the general population of Maine. Results of the analysis indicate that consumption of fish had a minor impact on the body burdens of anglers. This suggest that control of this source of exposure does not result in a significant reduction of angler's total exposures.

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09

POWER[1] M., L.S. MCCARTY[2]

TRENDS IN THE DEVELOPMENT OF ECOLOGICAL RISK ASSESSMENT AND MANAGEMENT FRAMEWORKS

Ecological risk assessment and management has grown from a long history of assessment and management activities aimed at improving the everyday lives of humans. The background against which ecological risk assessment and management have developed is discussed and recent trends in the development of risk assessment and management frameworks documented. Seven frameworks from five different countries are examined. All maintain an important role for science, suggest adaptive approaches to decision-making and have well defined analytical steps. Differences in approaches toward the separation of policy and science, the preference for management over assessment, the inclusion of stakeholders, the iterative nature of the analytical cycle, the use of decision criteria and economic information suggest considerable evolution in framework design over time. Despite the changes, no consensus on the design of a framework is apparent and work remains to be done on refining an integrative framework that effectively incorporates both policy and science considerations for environmental management purposes.

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P1

BEKAERT[1] C., J. MARTY[1], A. PFOHL-LESZKOWICZ[2], L. GAUTHIER[1], V. FERRIER[1]

EROD, DNA ADDUCTS AND MICRONUCLEI AS BIOMARKERS OF GENOTOXICITY IN *XENOPUS LAEVIS* ENVIRONMENTAL APPLICATION

Because of their genotoxicity, a large number of polycyclic aromatic hydrocarbons present in the environment pose an increasingly important ecological problem and a c arcinogenic risk to man. A biological approach using larvae of the amphibian *Xenopus laevis* to evaluate *in vivo* the genotoxicity of pure chemicals and complex matrices has been developed. The use of this lower vertebrate, treated in its rearing medium integrates physiological mechanisms which modulate the three biomarkers studied : ERCD activity, DNA adducts and micronuclei. Firstly, Benzo(a)Pyrene was used as model compound to study the three biomarkers as a function of the applied doses and the exposure time. Secondly, an industrial soil contaminated with cokery residues was used to represent an environmental application. An aqueous soil extract (leachate of soil IV) was prepared by the IRH. Environment in accordance with the AFNOR x 31-210 standards (ratio soil-water 1/10, 24 h agitation, 24 h decantation but without filtration at 0.45 µm) and tested with different dilutions. The results showed : i) a positive response in micronuclei at the first two dilutions, ii) induction of EROD activity according to the dilutions, iii) DNA adducts formation. The three biomarkers have provided complementary informations enabling the evaluation of genotoxic hazards to be refined. Overall, the use of this aquatic model is an original approach to evaluate the impact of solid compartment pollution on the genotoxic potential of the aqueous compartment by the method of lixiviation, which mimics streaming an lesivage occurring naturally in soils. This work is supported by the A.D.E.M.E. (Agence de l'Environnement et de la Maîtrise de l'Énergie).

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P2

WHELLY[1] M.P., J.J.H. CIBOROWSKI[1]

ASSESSMENT OF OIL SANDS PROCESS WATER TOXICITY IN WETLANDS OF NORTHERN ALBERTA USING CHIRONOMID MENTUM DEFORMITIES

The effects of oil sands process water (OSPW) on aquatic invertebrates in wetlands near Fort McMurray, AB, were assessed. OSPW is saline, and contains trace metals, PAHs and other hydrocarbons (mainly naphthenic acids). Principal components analysis and cluster analysis of environmental characteristics (water pH, conductivity, salinity, dissolved oxygen, sediment particle size distribution and organic content) of 15 wetlands were used to identify three pairs of environmentally similar wetlands that differed mainly in exposure to or absence of OSPW. Dip net sampling was performed to assess invertebrate community composition (taxa richness and abundance). We also tabulated mouthpart deformities in midges (Diptera: *Chironomidae*), a teratogenicity biomarker associated with reduced emergence success. Large larvae (250 per wetland) were hand-collected and examined for mentum deformities (extra or missing teeth). Invertebrate taxa (family) richness was moderately but not significantly lower at OSPW affected wetlands compared to corresponding reference sites (1-tailed paired comparison *t*-test, $p = 0.07$). There was no difference in abundances ($p > 0.1$). Chironomid taxa (genus) richness also did not differ ($p = 0.42$). The incidence of deformities in chironomids from OSPW affected and corresponding reference wetlands ranged from 1.43.7% and 0.0-2.8%, respectively. Incidence of deformities was homogeneous among sites (*G*-statistic = 5.0051, $p > 0.5$) and between paired reference and OSPW affected wetlands (*G*-statistic test of independence, $p > 0.1$ in all 3 cases). The suspected teratogens in OSPW (trace metals, PAHs) may not be bioavailable in these highly humic wetlands.

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P3

EASTON[1] M.

ASSESSMENT OF NUCLEAR DNA DAMAGE IN THE RED BLOOD CELLS OF VARIOUS POPULATIONS OF JUVENILE CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*) IN KITIMAT ARM

Blood was collected from juvenile chinook salmon populations from 5 different locations in the Kitimat region. Three sites (Kitimat Hatchery, Little Kildala Arm and Kemano) were considered reference locations with no pollution. Two sites (Yacht Basin and Alcan Beach) had various degrees of pollution from polycyclic aromatic hydrocarbons (PAHs). DNA damage was assessed using flow cytometry. The degree of variation in the nuclear DNA for each fish was summarized by the Coefficient of Variation (CV) statistic. This fish CV value was then subtracted from an internal control CV value to give a control corrected value, the DIF value which was subsequently analyzed using the weighted least squares method. The results from the ocean sampling indicated that the Yacht Basin was by far the most genotoxic site compared to Alcan Beach. Alcan Beach was more genotoxic than either of the ocean reference sites (Little Kildala Arm and Kemano). The two reference sites did not differ from each other. The fish sampled in the Kitimat Hatchery from both the Kildala stock and the Kitimat River stocks showed a much greater degree of genotoxic response than any of the ocean sampling locations. This result was surprising and several hypotheses are suggested to explain this phenomenon. The implications of genetic damage are discussed.

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P4

MIKAELIAN[1] I., Y. DE LAFONTAINE[2], C. MENARD[2], J.C. HARSHBARGER[3], D. MARTINEAU[1]

TUMORS AND CONTAMINANTS IN LAKE WHITEFISH (*COREGONUS CLUPEAFORMIS*) FROM THE ST.LAWRENCE RIVER, QUEBEC, CANADA

The prevalence of hepatic neoplastic and non-neoplastic lesions in some fish species has been attributed to the presence of chemical carcinogens in aquatic ecosystems. Lake whitefish (*Coregonus clupeaformis* ; n = 333) were collected from the St.Lawrence River, Quebec, Canada, to determine the prevalence of lesions present in major organs and levels of chemical contaminants in the tissues of these fish.

Major findings were observed in the liver and consisted of clear cell foci (4), vacuolated foci (50), basophilic foci (2), eosinophilic foci (4), hepatocellular carcinoma (6), cholangioma (1) and cholangiocarcinoma (15). Tumors in other organs consisted of one pyloric mucinous carcinoma, one metastatic Sertoli cell tumor, one chondrosarcoma of the gills, one fibrous meningioma, two poorly differentiated malignant meningeal tumors, one intestinal leiomyoma and one splenic hemangioma.

The mean concentration for Aroclor 1254, endrine, mirex, photomirex and copper was several fold higher in lake whitefish than in three other fish species captured at the same site.

This is the first series of hepatic tumors in a wild salmonid species. Lake whitefish, because of its wide distribution in north american freshwater, is potentially an excellent indicator of sediments contamination by carcinogens.

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P5

HANSEN[1] P.D., H. DIZER[1], V. BISSINGER[1], H. SILVA DE ASSIS[1]

RECENT STUDIES OF MARINE FISH AND BIVALVES FOR BIOMARKER BASED POLLUTION MONITORING IN THE NORTH SEA AND BALTIC SEA

Selected procedures for the determination of effect related biomarkers for neurotoxicity, genotoxicity and immunotoxicity were standardized and transformed into a biomarker index.

Results of biochemical responses such as brain cholinesterase activity and genotoxicity showed seasonal and site specific levels. The activity of glutathione-s-transferase varied according to the different physical parameters such as temperature. The variability in brain cholinesterase activities among individual fish was relatively small relative to the variability found in the mussels. The results of our study supports our thesis regarding the use of a battery of biochemical responses for pollution monitoring. Our results shed light on the dynamics of the detoxification activity, immunotoxicity and genotoxic potential in the organism.

Contaminated sediments exposure experiments were investigated with *Mytilus edulis* to quantify neurotoxicity by the cholinesterase activity, genotoxicity by the DNA unwinding assay and umu-assay and immunotoxicity by phagocytosis. The measurements of the phagocytic activity offers ample opportunities for detection of unknown biotoxins by their influence on mussel immunology. Beside the immunotoxic potential also the status of the sediments concerning environmental hygiene (mirobiology) was determined by counting *E.coli*, *Coliphages* and *Enterococcus*.

The paper outlines the application of currently available biomonitoring tools to generate information on early warning signals of ecosystem damage due to both man-made and natural pollution. Emphasis is placed on the use of recently developed online monitoring approaches and potential microscale techniques to assess environmental damages by a biomarker index and to manage ecosystem health.

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P6

BLAISE[1] C., F. GAGNÉ[1], S. TROTTIER[1], L. MÉNARD[1], J. PELLERIN[2], P.D. HANSEN[3]

ÉTUDES DE BIOMARQUEURS DES MOLLUSQUES BIVALVES (*MYA ARENARIA*) DU FJORD DU SAGUENAY, QUÉBEC, CANADA

Une démarche faisant appel à l'emploi d'un ensemble de biomarqueurs fut exploitée dans le but d'obtenir un certain portrait du " pouls écotoxique " du fjord du Saguenay, un tributaire majeur de l'écosystème Saint-Laurent potentiellement soumis à des stresseurs chimiques d'origines multiples. À cette fin, le mollusque bivalve endobenthique *Mya arenaria*, dont la présence est ubiquiste dans les platins intertidaux de ce cours d'eau, fut sélectionné comme bioindicateur pour mesurer différents types de biomarqueurs (biochimiques, physiologiques, immunologiques et histologiques) à sept stations d'échantillonnage. Six de celles-ci furent localisées dans le fjord lui-même (de son embouchure jusqu'à 70 km en amont), alors que la septième se situait à l'est de son embouchure - dans le Saint-Laurent - bien à l'extérieur de l'influence des principales sources de pollution pouvant affecter le Saguenay. En général, les réponses mesurées chez *Mya arenaria* ont présenté des variations spatiales et temporelles, suggérant ainsi la présence d'une contamination diffuse et multiple en origine qui semble affecter certaines régions plus fortement que d'autres.

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P7

BROUSSEAU[1] P., A. LACROIX[2], D. CYR[3], M. FOURNIER[3]

EFFECTS OF MARINE SEDIMENTS CONTAMINANTS ON THE IMMUNE COMPETENCE OF BIVALVES AND PLAICE

Contamination with PAHs, PCBs, and PCDFs makes Baie des Anglais one of the most contaminated area of the St. Lawrence Estuary. Fishes and bivalves living in the estuary are exposed continuously to these xenobiotics and these studies were conducted to determine if their immune system was a target to these contaminants. In one study, American plaices (*Hippoglossoides platessoides*) were exposed *in situ* for 3 weeks, to sediments from three different sites in and near Baie des Anglais: Site 1 being the closest to industrial discharges. The phagocytosis was evaluated by flow cytometry. The results show site 1 as being the most immunotoxic followed by sites 2 and 3.

In another study, American plaice and two species of bivalves (*Mactromeris polynima* and *Mya arenaria*) were exposed *in vivo* to sediments from site 1 followed by a period of rehabilitation for the American plaice. Phagocytosis was inhibited in fishes exposed to the contaminated sediments but it returned to control level after the rehabilitation period. For the bivalves, we observed an inhibition of the phagocytosis for *Mactromeris polinima*, but not for *Mya arenaria*. These studies indicate that contaminants present in the sediments are bioavailable to fishes and bivalves and they significantly impair their immune system.

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P8

DUBÉ[1] M.G., D.L. MACLATCHY[1], K.A. ELLIOTT[1]

SOURCES OF CONTAMINANTS IN THE BLEACHED KRAFT PULPING PROCESS AND THEIR EFFECTS ON *FUNDULUS HETEROCLITUS* (MUMMICHOG)

The effects of three effluents from a bleached kraft pulp mill on growth, condition, mixed function oxygenase (MFO) induction and plasma and *in vitro* steroid hormone production in *Fundulus heteroclitus* were assessed in August of 1997. Sexually mature males and females were exposed to 1% concentrations of either post-oxygen washer filtrate, clean condensate or bleach plant effluent in a flow-through mesocosm/field bioassay for 30 days. Survival, growth, condition factor and gonad weight were not affected by exposure to any of the three effluents. Liver weight and plasma testosterone levels may be affected by exposure to effluent from certain mill processes. Although plasma testosterone levels appear to be decreased by exposure to bleach plant effluents, no clear trends are evident between effluent type and liver weight. *In vitro* steroid hormone production and MFO analyses are presently being completed. A second mesocosm study is underway in which adult and juvenile *Fundulus heteroclitus* are being exposed to different effluents from the kraft process in varying concentrations. Improvements in the study design (*e.g.,* increased length of exposure) have been implemented in the second field season in order to clarify any differences that might exist in fish exposed to the various effluent streams.

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Q1

DUNCAN[1] W., B. ANTCLIFFE[2]

TOXICITY ASSESSMENT OF EFFLUENT FROM THE COMINCO METALLURGICAL AND FERTILIZER OPERATIONS AT TRAIL, B.C.

Cominco Limited and the Department of Fisheries and Oceans conducted a toxicity assessment of effluent from the Cominco Metallurgical and Fertilizer Operations at Trail, B.C. The assessment was conducted in the fall of 1996, prior to the installation of the new KIVCET smelter, as part of an integrated strategy for review of Cominco's effluent permit (PE-2753). The purpose was to develop and apply a Toxic Unit Model, as a planning and prioritization tool, to identify the toxic components of the effluent and a tributary stream (Stoney Creek), and to set preliminary acute toxicity targets for permit review and refinement of Cominco's Environmental Management Plan. Seven different toxicity assessments were conducted, each differed in the degree of conservatism and the data set used. All metals data were examined in dissolved form, as this is the form that contributes to acute toxicity. Results from all assessments produced a weight-of-evidence approach, indicating that the key toxic components of the effluent were: Combined II - Cd followed by Zn; Combined III - Cd followed by Zn and then un-ionized ammonia (with further research required for Tl); Combined IV - un-ionized ammonia followed by Cd and Zn; and Stoney Creek - Cd followed by Zn. Acute toxicity targets for all metals were recommended. The toxicity assessment was repeated in 1998, approximately 6 months after the new smelter was operational. Results indicated a reduction in toxicity of effluent from the smelter, and improved water quality in Stoney Creek.

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Q2

BAILEY[1] H.C., E. CANARI[1], P.M. CHAPMAN[1]

MINE EFFLUENT-RELATED TOTAL DISSOLVED SOLIDS (TDS) AND WATER QUALITY CRITERIA

Measurement of total dissolved solids (TDS) represents an integrative measure of the concentrations of common ions (e.g., sodium, potassium, calcium, magnesium, chloride, sulfate and bicarbonate) in freshwaters. Toxicity related to these ions is due to the specific combination and concentration of ions, and is not predictable from TDS concentrations. However, despite this, regulatory bodies have set TDS limits for freshwater bodies, generally related to chloride and other salt concentrations in a stream. Most TDS toxicity studies have been conducted with the "aquatic white rat" organisms used routinely for effluent toxicity tests (e.g., daphnids, fatheads). There is little information on TDS toxicity to other organisms. We conducted chronic toxicity tests with more environmentally relevant organisms (larval chironomids and eyed trout eggs) to assess their TDS tolerance relative to effluent from two Alaskan mines. Both effluents are characterized by high TDS content in addition to trace metals, however one effluent had much higher alkalinity than the other and contained a higher relative concentration of chloride, whereas the other was primarily sulfate-dominated. Tests with synthetic effluent demonstrated non-toxicity in the former case at >2,000 mg/L TDS to both test organisms; the latter effluent was found to be similarly non-toxic to developing trout eggs but chironomids showed effects above 1,000 mg/L TDS. These two tests, together with information on the health of field populations (fish and benthic invertebrates), appear to be useful and relevant for determining site-specific whole effluent TDS concentrations.

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Q3

BAILEY[1] H.C., J. ELPHICK[1], L. GIDDING[2], R. KRASSOI[2], A.M. MULHALL[2], L. TODHUNTER[2], P. HUNT[2], .BICKFORD[3], A. LOVELL[3]

RESULTS OF WHOLE EFFLUENT TOXICITY TESTS AND TOXICITY IDENTIFICATION EVALUATIONS CONDUCTED ON SEWAGE TREATMENT PLANT EFFLUENT DISCHARGED INTO THE HAWKESBURY-NEPEAN RIVER SYSTEM, NEW SOUTH WALES, AUSTRALIA

Effluent samples from 18 sewage treatment plants were evaluated for toxicity with *Ceriodaphnia dubia* and *Selenastrum capricornutum*. Acute and chronic toxicity was observed with *C. dubia*, but none of the samples tested to date resulted in adverse effects on algal growth. Toxicity of selected samples was associated with ammonia and the pesticides diazinon and chlorfenvinphos. Additional samples exhibited toxicity that was due to a non-polar organic chemical(s). However, toxicity in these samples dissipated within 48 hr which made identification of the toxic constituent(s) problematic. This presentation will describe the methods and results of the study, with particular emphasis on the procedures used to identify the factors associated with toxicity.

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[3] Sydney Water, Sydney, New South Wales, Australia

Q4

ABERNETHY[1] S.

EFFLUENT MONITORING RESULTS FOR CHRONIC SUBLETHAL TOXICITY

Ontario's MISA regulations cover 192 wastewater dischargers grouped in nine industrial sectors, such as the petroleum and the pulp and paper sectors. MISA requires extensive monitoring and reporting of effluent acute and chronic toxicity. Dischargers monitor their effluent for compliance with a toxicity limit based on acute lethality to rainbow trout and *Daphnia magna*. Those that maintain compliance with the limit also monitor their effluent for chronic sublethal toxicity to fathead minnow (growth inhibition) and *Ceriodaphnia dubia* (reproduction inhibition). All toxicity tests are performed according to standard Canadian national procedures. For each effluent test sample, dischargers report a graph of effluent concentration versus sublethal response (percentage reduction in growth or reproduction) and an IC25 summary statistic. So far, chronic sublethal test results are available for 89 samples. Forty-one of the samples had no sublethal effect (IC25 > 100% v/v) on either test species, while the other 48 samples did have a sublethal effect (IC25 < 100%) on one or both species. Of these 48 samples, 12 samples had an IC25 < 30% and one sample had an IC25 < 10%. Substantially more data on effluent sublethal toxicity will be available by the time of the workshop. All the available data will be presented and discussed.

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Q5

PICKARD[1] J., P. MCKEE[2], J. STROIAZZO[3]

SITE SPECIFIC MULTI-SPECIES TOXICITY TESTING OF SULPHATE AND MOLYBDENUM SPIKED MINING EFFLUENT AND RECEIVING WATER

Toxicity tests were conducted using a receiving water and effluent from a mine in B.C. to investigate the potential site specific toxic effects of sulphate and molybdenum on various aquatic organisms. This study examined the response of organisms exposed to both receiving water and a mixture of receiving water and effluent both spiked with sodium sulphate. The species examined included the salmonid embryo, *Daphnia magna*, *Selenastrum capricornutum*, *Ceriodaphnia dubia*, Fathead minnow, *Hyalella azteca* and the aquatic moss *Fontinalis neomexicana*. Toxicity values varied depending on species, the salmonid embryo test being the most sensitive with EC50 values of 1090 and 1700mg/L sulphate. No effects on moss chlorophyll a or chlorophyll b concentrations were observed at sulphate concentrations up to the maximum level tested of 500mg/L. Results indicate that the draft water quality criteria of 100mg/L sulphate for the protection of aquatic life and 50 mg/L when aquatic mosses are present are overly conservative.

A 30 day salmonid embryo/alevin test was used to study the effects of high levels of molybdenum on a mixture of pit water and receiving water. At the highest concentration tested (90mg/L) there was no significant effect on mortality or rate of development of embryos or alevins between the exposed groups and the controls.

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[3] Noranda Mining and Exploration Inc.

R1

GILLIS[1,2] P.L., D.G. DIXON[1], T.B. REYNOLDSON[2], L.C. DIENER[1]

METALLOTHIONEIN AS A BIOMARKER FOR TRACE METAL EXPOSURE AND EFFECTS IN *TUBIFEX TUBIFEX* AND *CHIRONOMUS RIPARIUS*

The oligochaete, *Tubifex tubifex* and the chironomid, *Chironomus riparius* were used in the development of a biomarker to quantify metal exposure and effects in benthic invertebrates. Laboratory cultured animals were exposed to cadmium in artificially contaminated field sediment following Environment Canada's whole sediment toxicity test protocols. Following exposure, metallothionein concentrations were measured using a mercury saturation assay based on Dutton *et al.*, (1993). Metallothionein concentration does not appear to vary significantly with the life stage of *T. tubifex*, with the exception of an apparent increase in 34 week old young. The time required to induce an increase in metallothionein synthesis was determined by exposing *T. tubifex* to metal contaminated sediments using a time series experiment. Induction is rapid with a significant increase in metallothionein concentration ($p < 0.05$) after eight hours of exposure, reaching a maximum after 24 hours. Metallothionein concentrations in both invertebrates exhibit a dose response relationship with metal exposure. Reproductive output of *T. tubifex*, as determined by enumerating young and cocoons, and wet weight in *C. riparius*, were measured to determine if elevated tissue metallothionein concentrations correspond to ecologically relevant endpoints. Both *T. tubifex* reproduction, and *C. riparius* wet weight are negatively affected by metal exposure and inversely related to tissue metallothionein concentration. Significant differences are seen at much lower cadmium concentrations in the molecular endpoint, metallothionein, compared to the whole body endpoints of reproduction and growth. Metallothionein concentration is significantly higher than the control at 50 ppm Cd in *T. tubifex* and 0.3 ppm Cd in *C. riparius* whereas a significant decline in reproduction or growth occurs at 250 ppm and 10 ppm respectively.

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R2

DE LAFONTAINE[1] Y., F. GAGNÉ[1], C. BLAISE[1], G. COSTAN[1], P. GAGNON[1]

ÉTUDE DE LA VARIABILITÉ SPATIALE DE 5 BIOMARQUEURS MESURÉS CHEZ LA MOULE ZÉBRÉE DANS LE FLEUVE SAINT-LAURENT

Cinq biomarqueurs (ADN : cassures de brin d'ADN ; POL : peroxydation des lipides ; Vg : vitellogénine ; EROD : ethoxyresorufin ortho-dééthylase ; MT : métallothionéine) ont été mesurés dans les tissus mous de la moule zébrée, *Dreissena polymorpha*, afin d'évaluer la variation spatiale de la contamination dans le fleuve Saint-Laurent. A chacun des 13 sites répartis le long du corridor fluvial d'eau douce, 15 moules d'une étroite gamme de taille ont été soumises aux analyses. Chaque biomarqueur montre des différences significatives entre les sites mais le patron général de variabilité est peu prononcé et très similaire pour les marqueurs ADN, POL, Vg et, dans une moindre mesure, EROD. Le marqueur MT est celui qui discrimine le mieux les stations entre elles. Certains sites localisés en aval de la communauté urbaine de Montréal ou dans de larges marinas montrent des valeurs systématiquement élevées avec tous les biomarqueurs, suggérant ainsi l'effet de sources locales de pollution. Les résultats d'une analyse en composantes principales montrent que le marqueur MT est fortement corrélé aux différents métaux accumulés dans les tissus des moules, principalement Ni, Cr, Zn et Pb, alors que les autres marqueurs sont en corrélation nulle ou très faible avec ce groupe de contaminants. Le groupement hiérarchique des stations, suivi d'une analyse discriminante basée sur les réponses des biomarqueurs, révèle l'influence très forte des deux prin.ipales masses d'eaux («vertes et brunes ») qui caractérisent le fleuve Saint-Laurent.

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R3

COUILLARD[1,2] Y., O. PERCEVAL[1], A. GIGUÈRE[2], B. PINEL-ALLOUL[1], P. CAMPBELL[2], L. HARE[2]

METALLOTHIONEIN AS A BIOMARKER FOR METAL CONTAMINATION AND TOXIC EFFECTS IN FRESHWATER BIVALVES: FIELD VALIDATION WITH *PYGANODON GRANDIS* IN ABITIBI LAKES

We evaluate the use of metallothionein (MT) as an indicator of metal-induced effects in aquatic organisms. We have selected the filter-feeding bivalve *Pyganodon grandis* as our model organism. Our main objective is to demonstrate that there exists a mechanistic link between the intracellular speciation of the metals (degree of metal detoxification) and the manifestation of deleterious effects at the organism (physiology) and population (density, production, size-structure) levels. For this purpose, we have initially selected 22 lakes with resident mollusc populations but with contrasting degrees of metal contamination (year 1). Each of these lakes was characterized from a limnological perspective (i.e. habitat quality for *P. grandis*), at the geochemical level (i.e degree of metal contamination at the sediment-water interface) and in a biochemical context (i.e cytosolic metals, cytosolic [MT], incidence of metal 'spillover' in the mollusc gill cytosol). A subset of 10 lakes of similar trophic status, but differing in their degree of metal contamination and in the incidence of metal spillover was retained for the studies at the level of the organism and the population (this year no. 2). Results of the first two years of this project, currently underway, are presented.

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R4

LAFLAMME[1] J.S., Y. COUILLARD[2,3], P.G.C. CAMPBELL[3], A. HONTELA[1]

IMPAIRED PHYSIOLOGICAL RESPONSE TO STRESS AND HIGH LEVELS OF METALLOTHIONEIN IN PERCH (*PERCA FLAVESCENS*) FROM LAKES CONTAMINATED BY HEAVY METALS

The effects of heavy metals on the physiological capacity to respond to a physical stressor (confinement), and the levels of metallothionein in the liver and the interrenal tissue were investigated in Perch (*Perca flavescens*) from six lakes in the mining region of Abitibi, QuÈbec. The levels of zinc (Zn), copper (Cu) and cadmium (Cd) in the liver and the interrenal tissue increased gradually and significantly from the least to the most contaminated lakes. Hepatic metallothionein (MT) concentrations increased similarly, and there was a strong linear relationship (r^2 = 0.94) between MT and total metal (Zn, Cu, and Cd) content in the liver. Interrenal tissue MT also increased significantly, and showed a strong linear relationship (r^2 = 0.94) with Cu and Cd interrenal content. Following a standardized stress test, plasma cortisol and glucose were significantly higher in perch from reference lakes compared to contaminated lakes, but no difference in chloride plasma was observed. The response to *in vitro* stimulation by ACTH and dbc AMP of the interrenal tissue was compared between fish from a contaminated lake and a reference lake. The secretion following these two stimuli was significantly lower in fish sampled in the contaminated lake. The condition factor was significantly lower in perch from the most contaminated lakes. This study demonstrated that a chronic exposure to heavy metals induces a highly significant increase of hepatic and interrenal tissue MT concentrations, and may disrupt the physiological capacity of perch to respond to a stressor.

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R5

TRUDEL[1] L., J.F. KLAVERKAMP[2], D. FARARA[3], P. MCKEE[3]

ÉVALUATION DE LA MÉTALLOTHIONÉINE DANS LES TISSUS DES POISSONS COMME INDICATEUR D'EXPOSITION : ÉTUDES DE CAS À TROIS SITES MINIERS CANADIENS

Le Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ÉTIMA) vise à évaluer plusieurs méthodes de surveillance des effets des exploitations minières sur les écosystèmes aquatiques. La métallothionéine joue un rôle dans la régulation et la détoxification de plusieurs métaux. La littérature indique qu'elle fournirait des données complémentaires à l'analyse des métaux dans les tissus des organismes aquatiques. Son utilisation comme biomarqueur pour évaluer le niveau d'exposition des organismes aux métaux aiderait à répondre à la question Les contaminants sont-ils biodisponibles?. En 1997, des poissons ont été récoltés à proximité de trois sites miniers canadiens: Heath Steele (Miramichi, N.B.), Mattabi (Ignace, Ont.), and Dome (Timmins, Ont.). L'analyse des teneurs en métallothionéine et en métaux a été effectuée sur deux espèces sentinelles et plusieurs tissus (foie, reins, branchies, viscères). Les résultats préliminaires démontrent que la métallothionéine était partiellement efficace à indiquer des différences significatives entre les stations exposées et témoins chez une seule des deux espèces, et ce à deux sites. Aucun tissu particulier ne s'est révélé plus efficace, les teneurs variant parmi les tissus, les espèces et les sites. Certains facteurs (rejet intermittent, déplacement des poissons, durée d'exposition, contenu alimentaire) pourraient expliquer la faible capacité de la métallothionéine à démontrer des réponses constantes. Les teneurs en métaux dans les tissus se sont révélés plus efficaces en reflétant plus fréquemment le niveau d'exposition réel. Des considérations d'ordres pratiques (laboratoire, coûts analytiques, prélèvement et préservation des échantillons) sont examinées. Ces données suggèrent que l'application de cette méthode comme outil de surveillance reste à établir et plusieurs aspects demeurent à développer.

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[2] Freshwater Institute, Department of Fisheries and Oceans, Winnipeg, MB
[3] BEAK International Inc., Brampton, ON

S1

GUAY[1] I.

LES CRITÈRES DE QUALITÉ DE L'EAU À LA BASE DES OBJECTIFS ENVIRONNEMENTAUX DE REJET (OER) DU MEF

Le milieu aquatique, en plus d'être le milieu de vie essentiel de tous les organismes aquatiques, est aussi une ressource nécessaire tant pour l'alimentation humaine (prises d'eau potable, pêches sportive, commerciale et de subsistance) que pour celle de la faune terrestre et avienne qui s'y abreuve et s'y alimente. Il sert aussi à la pratique de bons nombres d'activités récréatives allant de la baignade à sa simple observation le long des parcs riverains, tout comme de source d'alimentation pour les prises d'eau industrielles ou l'irrigation des terres. Il n'en demeure pas moins le récepteur d'un très grand nombre de substances pouvant nuire à l'un ou à l'autre de ces usages ou aux organismes aquatiques.

Dans ce contexte le ministère de l'Environnement et de la faune (MEF) est responsable de l'établissement des exigences qui permettent le maintien et la récupération des usages de l'eau et des ressources biologiques. Pour ce faire, le Ministère doit entre autres élaborer des objectifs environnementaux de rejet (OER) pour les sources ponctuelles se déversant au milieu aquatique. Ces objectifs sont déterminés à partir de la connaissance des cours d'eau récepteurs dont la vulnérabilité diffère en fonction de leurs conditions hydrodynamiques, et du niveau de qualité nécessaire au maintien et à la récupération des usages réels et potentiels du milieu. Ce niveau de qualité nécessaire est représenté par des critères de qualité de l'eau qui prennent en compte les propriétés variables des substances et reflètent l'état actuel des connaissances sur les effets nuisibles des contaminants.

Le présent exposé a pour but de présenter les principes qui sous-tendent la détermination des critères de qualité de l'eau ainsi que ceux à la base de l'approche de protection du milieu aquatique et de ses OER.

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S2

RICHARD[1] F.

LES OBJECTIFS ENVIRONNEMENTAUX DE REJET (OER) ET LEUR CADRE D'APPLICATION

La conférence a pour but de présenter le cadre d'application des objectifs environnementaux de rejet (OER) au MEF principalement sous leurs aspects légaux, administratifs et scientifiques.

Les OER définissent (habituellement en termes de concentration et charge pour une substance donnée) les besoins du milieu aquatique pour la protection des usages. C'est l'outil que le MEF utilise comme base de l'évaluation de la susceptibilité d'un rejet à causer un effet prévisible dans le milieu aquatique.

D'abord développés et utilisés dans le cadre du Programme d'assainissement des eaux du Québec depuis le début des années 1980 (volets urbain, industriel et agricole), les OER sont utilisés aussi pour l'analyse des dossiers d'implantation de nouveaux établissements industriels et pour les dossiers des secteurs d'activités décrétés dans le cadre du Programme de réduction des rejets industriels. Le pouvoir d'utiliser les OER repose sur les articles 20, 22 et 24 de la Loi sur la qualité de l'environnement (LQE) et sur la section IV.2 de la LQE qui confère au ministre le pouvoir d'établir des normes sur la base du milieu récepteur.

Les OER sont utilisés en complémentarité aux outils technologiques (règlements et certificats d'autorisation) et servent d'appui à la prévention de la pollution en donnant, au besoin, des orientations de recherche et de développement technologique. De plus, les OER prennent en compte les différents tronçons d'un cours d'eau et leurs conditions hydrodynamiques , les limites de détection des méthodes analytiques et les lacunes dans les données des réseaux de mesure.

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S3

ROUISSE[1] L.

ANALYSE COMMENTÉE SUR LA MÉTHODE DE CALCUL DES OBJECTIFS ENVIRONNEMENTAUX DE REJET (OER) DU MINISTÈRE DE L'ENVIRONNEMENT ET DE LA FAUNE DU QUÉBEC

L'industrie papetière québécoise et le ministère de l'Environnement et de la Faune du Québec (MEF) travaillent présentement à la mise en œuvre de la première génération d'attestations d'assainissement. Les attestations d'assainissement représentent une forme de permis où seront regroupées les exigences réglementaires auxquelles sont présentement assujetties les papetières. Par ailleurs, à compter de la deuxième génération, les attestations d'assainissement pourront inclure des limites de rejets élaborées sur la base des impacts sur le milieu récepteur. Ces limites seront définies à partir d'objectifs environnementaux de rejet (OER) calculés par le Ministère. Elles cibleront distinctement la protection de l'eau, de l'air ou des sols.

Récemment, les papetières ont reçu du MEF des valeurs préliminaires d'OER pour le milieu aquatique. Dans le cadre d'un mandat confié par l'Association des industries forestières du Québec, à Sanexen Services Environnementaux inc. , les diverses étapes de la méthode de calcul des OER du MEF ont été examinées et commentées. Les résultats sommaires de cette étude seront présentés dans le cadre de cette présentation.

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PO-01

BAILEY[1] H.C., E. CANARIA[1], J. ELPHICK[1]

FURTHER APPLICATIONS OF SALMONID FERTILIZATION TESTS

We have previously described modifications to the dry fertilization technique originally promulgated for use in conducting early life stage toxicity tests with salmonids by Environment Canada. Since that time, we have applied the modified techniques successfully to coastal cutthroat trout and chum salmon. Moreover, we have also developed a laboratory method for wet fertilization for use in instances where effects on sperm and the fertilization process are also of interest. This presentation will describe the methods associated with the different procedures, as well as modifications required for different species. Overall, our experience suggests that these tests can be conducted with a range of salmonid species, provided that appropriate modifications are applied.

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PO-02

BOIVIN[1] P., P. SIMARD[1], C. GAGNON[1], R. LETARTE[2]

RECHERCHE DE NOUVEAUX INDICATEURS POUR L'ÉVALUATION DE TOXICITÉ: MICROORGANISMES ET LIGNÉES CELLULAIRES

L'industrialisation en croissance constante nous incite à bien évaluer l'importance des rejets industriels dans les écosystèmes. Afin de diminuer le temps, l'espace et les coûts reliés aux essais écotoxicologiques conventionnels, nous nous sommes attardés à chercher un indicateur bactérien de pollution ainsi qu'une lignée cellulaire pouvant corréler les résultats des bioessais. L'étude a porté sur 199 échantillons provenant de 7 usines de pâte et papier et d'une pétrolière. Les bactéries recherchées étaient les coliformes totaux et fécaux, les streptocoques fécaux, les *Klebsiella sp.*, les *Aeromonas sp.* et le *Pseudomonas aeruginosa*. Les résultats montrent en général aucune corrélation directe avec ceux obtenus par bioessais conventionnels. Des résultats préliminaires concernant les coliformes totaux et *Aeromonas sp.* montrent une meilleure cohésion. Parallèlement, des essais de cytotoxicité ont été effectués avec les lignées cellulaires CHO, 3T3, 293, Vero et Pa1. Les meilleurs résultats ont été obtenus par la lignée Pa1 qui, pour les effluents toxiques par méthodes conventionnels, répondait positivement dans 50% des cas. Pour ce qui est des autres lignées cellulaires les résultats sont non significatifs. En conclusion, aucune des lignées cellulaires testées a la possibilité de discerner les effluents toxiques des effluents nontoxiques de façon adéquate. De plus, aucun des genres bactériens coliformes fécaux, *Klebsiella sp.*, *Pseudomonas aeruginosa* et streptocoques fécaux ne peuvent servir d'indicateur de toxicité. En ce qui concerne les coliformes totaux et les *Aeromonas sp.*, les résultats préliminaires sont plus prometteurs et donnent lieu à une étude plus approfondie.

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PO-03

CROISETIÈRE[1] L., R. CARPENTIER[2]

MISE AU POINT D'UN BIOESSAI DE PHYTOTOXICITÉ SUBLÉTALE SURAIGUË SUR *SYNECHOCOCCUS LEOPOLIENSIS* : L'APPORT DE L'ÉLECTROCHIMIE

Nos travaux ont porté sur la mise au point d'un bioessai de très courte durée utilisant des cyanobactéries, organismes photosynthétiques d'une structure simple. L'utilisation de ces organismes entiers dans une cellule électrochimique nous a permis de mesurer l'activité de la chaîne de transport d'électrons de l'appareil photosynthétique sans intermédiaire chimique. Cette mesure du transport d'électrons est en relation directe avec le rendement de l'appareil photosynthétique. La mesure de cette même activité nous a donc permis d'évaluer la sensibilité des cyanobactéries à divers toxiques pour ainsi évaluer la viabilité de la technique à deux groupes d'inhibiteurs : les cations métalliques divalents et les herbicides. L'inhibition complète du signal lors de l'exposition des cyanobactéries à un inhibiteur connu de la chaîne de transport d'électrons (Diuron) nous a permis de démontrer que le signal provenait bel et bien de l'activité photosynthétique. Nous avons également noté que la sensibilité du bioessai était beaucoup plus grande avec les herbicides qu'avec les métaux. Par exemple, nous avons obtenu une inhibition de 50% du signal avec 8,1mg·L^{-1} de Cu alors qu'il ne fallait que 0,35 mg·L^{-1} de Diuron pour obtenir la même inhibition du signal.

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PO-04

FENNELL[1] M., J. BRUNO[1]

MODIFICATIONS TO ENVIRONMENT CANADA'S EARLY-LIFE-STAGE (ELS) TESTS USING SALMONID FISH (THE "EMBRYO" AND "EMBRYO/ALEVIN" TOXICITY-TEST OPTIONS)

Environment Canada's Biological Test Method Report EPS 1/RM/28 describes three options for early-life-stage toxicity-testing using salmonids. Laboratory studies compared the sensitivity of, and improved procedures/conditions for, both the 7-day embryo (E-)test, and the longer embryo/alevin (EA-) test, each initiated with freshlyfertilized eggs. Sideby-side ELS-test comparisons were performed along with a suite of short-term acute and chronic bioassays using negative and positive control treatments and weekly samples of BKME and CTMPE. The salmonid E-test and the 7d Fathead Minnow test were compared using potassium toxicity data. Recommendations on: species choice; fertilization and test initiation (procedure/timing); reference toxicant test performance; and EA-test duration and test temperature regime will be presented. Studies revealed that the longerterm EA-test allows for the collection of more information (i.e. not limited to the single endpoint of embryo non-viability) and more revealing evidence of adverse biological effects than the 7d E-test (e.g. abnormal development becomes obvious; similar effects occur at lower concentrations). Final recommendations for the E- and EA-test include: testing at 14±1°C, and the use of Abbott'scorrected percentages for all EC50/EC25 determinations. The E-test assesses embryo nonviability 7 days after fertilization. We recommend terminating the EA-test 7 days after ≥50 %-control hatch (test duration ˜29 days) collecting observations and narrative reports of alevin-deformity and delay in hatching, and numerical records of non-viable embryos, dead alevins, and cumulative mortality for calculations of EC50/EC25.

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PO-05

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DEVELOPMENT OF ENVIRONMENT CANADA'S 14-DAY SURVIVAL-AND-GROWTH TEST FOR MARINE SEDIMENTS USING LABORATORY-CULTURED SPIONID POLYCHAETES

Since 1992 methodology describing subchronic-toxicity testing using marine polychaetes has been in evolution. Several developmentphases have investigated: species-suitability; test-duration, -temperature, -age and food-type; response in contaminated sediments; and influences of particle size and ammonia. Due to variability of field-collected organisms (size, age), cultures of *Polydora cornuta* (East Coast) and *Boccardia proboscidea* (West Coast) have been maintained at our Atlantic and Pacific regional laboratories for ongoing design of an effective, reproducible test. Recent efforts at the Pacific laboratory involved: food ration, ammonia-buildup/water-renewal schedule, and vessel size comparisons; a two-phase interlaboratory method-validation (preparation/participation, organism-supply); and species evaluations for survival-and-growth response and culturing efforts using five years of (rearing/testing) data. Significant findings include: the routinely-used 1L-jar-with-200Ml-sediment setup and 5mgfood/worm/feeding was excessive for organism size; and *B. proboscidea* is less sensitive, illsuited for detecting sublethal/growth effects, more difficult to culture and frequently provides too few testage juveniles for setup due to lower reproduction rates and poor survival/settling. To date, efforts and commitment required (labour, time, luck?) for organism-supply and test initiation/teardown negate this bioassay from becoming a test, like that for 10-d amphipod-survival, for laboratories to routinely process numerous samples. To summarize recommendations for a less labour-intensive, more reliable and standardized microscale test: 300mL(tallform)-beaker-with-50mL-sediment (quicker/easier teardown), 2mg-food/worm/feeding, using *P. cornuta* (more sensitive, easier culturing, rare shortages) from cultures established by test users (with initial guidance from experienced Environment Canada researchers).

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PO-06

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INTERCALIBRATION STUDY FOR THE EVALUATION OF TOXICITY WITH RAINBOW TROUT HEPATOCYTES

The transferability and reproducibility of the rainbow trout hepatocyte cytotoxicity test was studied with an intercalibation exercise. Rainbow trout hepatocytes were plated in 96well microplates and send to different laboratories (8) at 4°C in styrofoam ice boxes. Each laboratory was instructed to initiate exposure on two blinded samples for 24 h where one of those proved to be toxic while the other was not toxic. They were also instructed to evaluate cell viability either with the propidium (PI) exclusion test or with the neutral red uptake (NRU) assays. These two assays were proposed to accommodate laboratories' constraints (i.e., available spectrophotometers or fluorometers, microplate vs tube centrifuges). The results showed that all groups were able to identify the toxic sample from the nontoxic one. The cytotoxic concentration that kills 50 % of the hepatocyte (CC50) varied between 70131 mM when cell viability was determined with the PI test while the CC50 values varied between 82118 mM with the NRU assay. These values were in the same range with the data obtained in our laboratory (quality control chart). Therefore, the rainbow trout hepatocyte cytotoxicity evaluation test appears to be reproducible and transferable to other laboratories; these would produce statistically the same classification/results on the measurement endpoints such as the identification of the (non)toxic samples, the lowest observable effect concentration and the CC50 values.

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PO-07

BENGUIRA[1] S., A.C. RICARD[1], J.P. WEBERT[2], A. HONTELA[1]

ADRENOTOXIC EFFECTS OF o,p'-DDD, p,p'-DDD AND p,p'-DDT IN RAINBOW TROUT, *ONCORHYNCHUS MYKISS, IN VIVO* AND *IN VITRO*

The o,p'-DDD, a metabolite of DDT, has been identified as a potent adrenolytic chemical in birds and mammals. The effects and mechanisms of action of o,p'-DDD on adrenal steroidogenesis were investigated in rainbow trout (*Oncorhynchus mykiss*) in a dose-response study, *in vivo* and *in vitro*. A reduced capacity to elevate plasma cortisol in response to stress (30 sec net confinement) and at rest was observed 14 days after i.p. injection of 20 and 50 mg/kg o,p'-DDD. Hepatic glycogen levels were lower in stressed fish treated with 20 and 50 mg/kg o,p'-DDD. To further elucidate the effects of o,p'-DDD, fragments of interrenal tissue were incubated in complete medium and exposed to o,p'-DDD, p,p'-DDD or p,p'-DDT for 5 hours. The capacity to respond to ACTH (1 IU/ml) or dbcAMP (2 mM) was evaluated and tissu viability was assessed. A decrease of ACTH-stimulated cortisol secretion was observed following exposure to 25, 50 and 100 mg/l of o,p'-DDD in the medium. An impairment of cAMP-stimulated cortisol secretion was detected at 50 and 100 mg/l of o,p'-DDD but not at 25 mg/l. These results indicate that o,p'-DDD is an adrenotoxic that may distrupt the cAMP step. The p,p'-DDT compound was less effective in suppressing ACTH- or cAMP-stimulated cortisol secretion since only interrenal fragments exposed to 100 mg/l were affected. The p,p'-DDD, a direct metabolite of p,p'-DDT, did not alter cortisol secretion at any dose studied. These results suggest that the p,p'- isomers are less potent adrenotoxics than the o,p'- isomers in rainbow trout.

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PO-08

BENSON[1] W.H., A.C. NIMROD[2] , W.C. COLLEY[1]

INTERACTION OF ENDOCRINE MODULATING SUBSTANCES WITH AND ALTERATION OF TELEOST ESTROGEN RECEPTOR

Estrogen receptor (ER) from channel catfish (*Ictalurus punctatus*) hepatic tissue was characterized by binding affinity for several compounds. Affinity was indirectly measured as potency of the chemical for inhibiting binding of radiolabeled estradiol (E2) to specific binding sites. The order of potency among endocrine modulating substances was: ethinylestradiol > E2 = diethylstilbestrol > mestranol > tamoxifen >> testosterone. Of the most potent inhibitors, nonylphenol (NP) appeared to be a competitive inhibitor for the same binding site as E2, while *o*demethylated methoxychlor had a more complex interaction with the receptor protein. In addition, NP was shown to significantly increase ER per milligram hepatic protein almost to the same extent as E2, but did not increase Kd to the same extent as E2. Further studies will be conducted to investigate the implications of such receptor population changes using sex steroid hormone receptors from the Japanese medaka (*Oryzias latipes*). Using RT-PCR with medaka ER specific primers and RNA isolated from liver of females exposed to E2, the medaka ER gene has been amplified and cloned. In addition to the predicted 1,775 base pair PCR product, products of 444 and 1,250 bp were obtained. Sequencing revealed that all three clones represent the medaka ER gene. The longest clone corresponds to the previously reported cDNA that encodes a 575 amino acid protein (ER-A). The shortest clone (ER-C) has been completely sequenced and encodes a 123 amino acid protein that lacks both the DNA binding domain and hormone binding domain.

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PO-09

BROWN[1] S.B , K. HAYA[2], L. BURRIDGE[2], E.O. SWANSBURG[3], J.T. ARSENEAULT[3], W.L. FAIRCHILD[3]

EFFECTS OF 4-NONYLPHENOL ON ATLANTIC SALMON (*SALMO SALAR*) SMOLTS

A recent evaluation of relationships between historical applications of Matacil® 1.8D to forested areas of Atlantic Canada and catch data for Atlantic salmon populations suggest possible declines in catch related to effects at the smolt stage. Matacil® 1.8D contains the carbamate insecticide aminocarb with 4nonylphenol (4NP) as a diluent. After spraying, reported aminocarb concentrations in water samples were well below reported lethal thresholds for Atlantic salmon. However, the estimated 4NP concentrations fell within a range where estrogenic effects in fish might be anticipated. The spray program was coincident with final stages of smolt development in salmon. There was a significant negative relationship between the returns of large Atlantic salmon and the proportion of individual tributaries sprayed in 1977. For 19 other spray events occurring in 14 rivers, 53 % of the lowest salmon catches between 1973 and 1990 coincided with times when Matacil® 1.8D had been sprayed. This experiment investigates the hypothesis that the 4-NP in the Matacil® 1.8D formulation may be the causal agent, and that there may be an estrogenic mechanism involved. We have exposed Atlantic salmon smolts to environmentally relevant, pulse doses of waterborne 4-NP, and sustained doses of estradiol (E2), during the latter stages of smoltification. The smolts capability to withstand sea water and their subsequent growth were evaluated after exposure to 20 and 200 µg/L 4-NP, and to 100 and 300 ng/L E2. There was no apparent mortality due to treatment during a sea water challenge soon after exposure, or after subsequent slow acclimation to sea water.

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PO-10

FOURNIER[1] M., I. VOCCIA [2], A. LACROIX [2], M. DUNIER [3], S. CHILMONCZYK [4], P. BROUSSEAU[5]

COMPARATIVE EFFECTS OF PULP MILL EFFLUENTS ON MACROPHAGE FUNCTION IN 3 SPECIES OF FISH

We studied the effects of pulp mill effluents on macrophage functions (phagocytosis and the respiratory burst) in three species of fish exposed *in vivo* to pulp mill effluents or captured in waters contaminated by pulp mill discharges. We present the results obtained on : 1) a 96 hour exposure of rainbow trout to pulp mill effluents comparing chlorine (ClO_2) and non chlorine (H_2O_2) bleaching, 2) a one month exposure of chinook salmon to pulp mill effluents comparing low oxygen (hypoxia) and normal oxygen conditions (normoxia) and 3) on male and female mummichogs captured in water contaminated by pulp mill effluents. For the rainbow trout, our results show that non chlorine bleaching is significantly more immunotoxic than chlorine bleaching. For the chinook salmon, hypoxic conditions inhibited phagocytosis to a greater extend than normoxic conditions. Finally, for the mummichogs we noted a suppression of macrophage functions in males and females but with a significantly higher suppression in females when compared to males. Results from these studies suggest that pulp mill effluents are immunotoxic to various fish species and that macrophage functions might be adequate biomarkers to assess immunotoxicity in fish.

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PO-11

LEBLOND[1] V., A. HONTELA[1]

EFFECTS OF XENOBIOTICS ON FISH INTERRENAL CELLS *IN VITRO* : USE OF CELL SUSPENSIONS

Cortisol, the major corticosteroid secreted by teleost fishes, is synthetized by interrenal cells in the headkidney. Previous studies demonstrated that its secretion is impaired in fish from sites contaminated with heavy metals. We describe a new method to evaluate *in vitro*, the effects of metals on rainbow trout interrenal steroidogenic cells. Interrenal cells dispersed with collagenase/dispase mixture enzyme were responsive to ACTH and dbcAMPin a dose-related manner. The effects of toxicants on ACTH-and dbcAMP-stimulated cortisol secretion (EC50, dose that inhibits 50% of cortisol secretion), on cell viability (LC50, dose that kills 50% of cells) and the possible protector role of zinc on cadmium toxicity were studied. Cadmium chloride (highest LC50/EC50 ratio) was the most toxic chemical tested , followed by zinc chloride, methylmercury and mercury chloride. Furthermore, the results showed that zinc chloride did not protect the interrenal cells against cadmium chloride toxicity. This method can be used to compare toxicity of chemicals on the interrenal steroidogenic cells and to elucidate the cellular mechanisms of action of pollutants.

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PO-12

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DEVELOPMENT OF AN *IN VIVO* ASSAY TO CHARACTERIZE THE REPRODUCTIVE EFFECTS OF INDIVIDUAL COMPOUNDS OR COMPLEX EFFLUENTS USING SEXUALLY IMMATURE RAINBOW TROUT

There is a need for short term whole animal assays to evaluate the effects of defined contaminants and complex effluents on the reproductive physiology of fish. Such assays are needed to establish cause and effect relationships following a chemical exposure which is rendered often difficult to demonstrate in feral fish due to habitat alterations. Furthermore, such assays would play an important role in rapidly evaluating the biological effects of effluents following technological modifications. We developed a 21 day protocol with daily renewal of the test solutions using sexually immature rainbow trout. The protocol was used to evaluate the effects of either single chemicals (17ß-estradiol (E_2), the environmental estrogen agonist nonylphenol and the plant sterol ßsitosterol) or pulp and paper mill effluents. The endpoints measured include plasma vitellogenin (Vtg), sex steroids, cholesterol and retinol. The assay was suitable to characterize a suite of responses mediated through estrogenic and other mechanisms of action in ß-sitosterol and pulp and paper mill effluent exposed fish. These studies demonstrated that estrogenic endpoints alone do not fully characterize the potential of compounds/mixtures to affect reproduction and there is a need to continue *in vivo* testing using endpoints integrating multiple mechanisms of action.

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PO-13

MASSICOTTE[1] R., D. FLIPO[1], M. FOURNIER[2], B. TROTTIER[1]

L'APPLICATION DE LA CYTOMÉTRIE EN FLUX POUR L'ÉTUDE DE L'IMMUNOTOXICITÉ DES FRACTIONS SOLUBLE ET INSOLUBLE DE POUSSIÈRES DE CIMENTERIE

L'étude des propriétés immunotoxiques peut grandement profiter des spécificités de la cytométrie en flux. Dans cette étude, nous avons développé une méthodologie permettant d'élargir l'étude de l'immunotoxicité à la fraction insoluble de poussières de cimenterie. Plus spécifiquement, nous avons étudié l'effet des poussières sur la phagocytose qui représente le principal mécanisme de défense chez les coelomocytes du ver de terre. Ceux-ci sont extraits des vers par massage dans un tampon salin (contenant de l'éther de guaiacol glycérol). La viabilité est vérifiée par l'exclusion du bleu de trypan et la phagocytose est mesurée après une incubation en présence de billes de latex fluorescentes. Les billes non phagocytées sont éliminées de la suspension cellulaire par centrifugation sur un gradient d'albumine de sérum de bœuf. L'utilisation simultanée de différents marqueurs fluorescents (iodure de propidium (PI) et diacétate de dichlorofluorescéine (DCFDA)) nous permet de discriminer sans ambiguïté les coelomocytes vivants des coelomocytes morts et des particules de poussières. L'ajout de billes de latex fluorescentes nous permet enfin d'évaluer le pouvoir phagocytaire des coelomocytes. Cet outil devrait trouver d'ici peu des applications dans d'autres domaines tels la caractérisation des propriétés toxicologiques de sédiments contaminés.

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PO-14

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A TIER II APPROACH TO DETERMINING SITE SPECIFIC TOXICITY OF A METAL AND HYDROCARBON CONTAMINATED SITE TO TERRESTRIAL ORGANISMS

A Tier 1 approach is based on guidelines that focus around chemical data to assess criteria for determining toxicity and /or suitability of soils for certain uses. A tier 11 study we undertook for a client involved conducting bioassays with terrestrial organisms. Various areas of a site that had shown high levels of metal and hydrocarbon contamination were sampled. Also, various depths at each site were sampled to get a picture of the depthprofile of the contamination. Initially, all samples were screened by Microtox™ analysis to get an idea of how relatively toxic each site was and to eliminate most of the relatively nontoxic sites. A battery of terrestrial tests were then set up on those sites showing extreme to slight toxicity to the Microtox™ analysis (as well as some of those sites showing no toxicity). It was found that the plant species were far less sensitive to the kind of contamination found at these sites and the earthworm showed hardly any toxic response. This study helped our client assess where there were 'hotspots' at the site, the extent of the contamination and also gave them an alternative assessment and criteria for remediation

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PO-15

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TOXICITY ASSESSMENT OF APPROVED DRILLING MUD ADDITIVES IN THE OIL AND GAS SECTOR

Surface disposal of drilling fluids has been approved by the Alberta Energy and Utilities Board (AEUB) under the jurisdiction of the Drilling Waste Management guideline (G50). Disposal is allowed without toxicity testing if the fluid is consistent with water based materials (as opposed to oil based) and all additives have been preapproved (list compiled by the Petroleum Services Association of Alberta, PSAC). The additives must pass a toxicity test to be included in the list (bacterial luminescence). A critical question is whether or not the bacterial luminescence test provides an adequate degree of ecological protection for surface disposal of drilling fluids.

A multitrophic level approach was applied to over 90% of the additives on the PSAC list. The tests included:

- microbes (bacterial luminescence, growth, respiration, genotoxicity)
- plants (seed emergence, root elongation, duckweed and algal growth)
- invertebrates (worm avoidance, survival of selected aquatic species)
- fish (fathead minnow survival, trout embryo development)

The test results were ranked and consolidated into a toxicity index for comparison to the bacterial luminescence test results. Overall, there was good agreement amongst the required bacterial luminescence test and the expanded multi-trophic level approach. However, the results support the use of a multi-trophic level approach because a number of products cannot be adequately evaluated with bacterial luminescence alone. Other issues dealing with what constitutes adequate ecological protection are discussed.

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PO-16

CARLE[2] N., J. HATCHER[1], J. FUJIKAWA[1], J.S. GOUDEY[2]

ASSESSMENT OF TOXICITY BASED CRITERIA FOR DISPOSAL OF DRILLING WASTE IN OIL AND GAS EXPLORATION

Options for the disposal of drilling wastes are defined by the Alberta Energy and Utilities Board (AEUB) under the jurisdiction of the Drilling Waste Management guideline (G50). Current guidelines incorporate the use of a bacterial luminescence test. However, only one test species is required and there is some concern as to whether or not this provides an adequate degree of environmental protection. Our objective was to apply an expanded test battery to a representative sample of drilling wastes in order to assess the adequacy of the bacterial luminescence test. The tests included:

- microbes (bacterial luminescence, growth, respiration, genotoxicity)
- plants (seed emergence, root elongation, duckweed and algal growth)
- invertebrates (worm avoidance, survival of selected aquatic species)
- fish (fathead minnow survival, trout embryo development)

Sixty drilling muds were tested; thirty of them were toxic to luminescent bacteria. A complete chemical characterization was done on all muds in order to interpret the test data. The biological test results were ranked and consolidated into a toxicity index. Overall, there was a broad range in species sensitivities to the drilling muds. Some good correlations were obtained amongst a number of species and luminescent bacteria. A multi-trophic level approach is recommended to ensure a greater assurance of ecological protection. However, the cost must be in line with the benefits.

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PO-17

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ECOTOXICOLOGICAL EFFECTS OF RECALCITRANT ENVIRONMENTAL POLLUTANTS ON TWO SPECIES OF SOIL INVERTEBRATES (*ENCHYTRAEUS ALBIDUS* AND *EISENIA ANDREI*)

Trinitrotoluene (TNT), its synthetic byproducts and microbial metabolites are recalcitrant pollutants derived from industrial practices related to peace and warfare activities. The evaluation of the environmental effects of these compounds would involve both analytical chemistry as well as ecotoxicological analyses. The effect of TNT on the lethality and reproduction of two different soil invertebrates species: the composting worm *Eisenia Andrei* and the white potworm *Enchytraeus albidus*, were studied using spiked OECD artificial soil. Data showed that both species responded similarly to TNT as evidenced by a decrease in fecundity. In addition, a decrease of TNT concentration in the soil in the absence of *Enchytraeus albidus* was observed, and may have been due to chemical as well as microbial processes. This work presents some of the problems incurred when using spiked artificial soil as a matrix to evaluate the potential of toxicity of TNT.

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PO-18

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TOXICITY ASSESSMENT OF CONTAMINATED SITE SOILS USING A BATTERY OF TERRESTRIAL SPECIES

The toxicity of soils contaminated with petroleum hydrocarbon mixtures (condensates or amines/glycols) were evaluated using a battery of terrestrial test species consisting of eight plant species (alfalfa, carrot, cucumber, northern wheatgrass, grama grass, radish, red fescue, and corn), three earthworm species (dew worm, red wiggler, and white pot worm) and a soil arthropod (onychiurid springtail). The definitive whole-soil tests involved exposing each test species to a range of concentrations formulated by diluting the contaminated site soil with a clean control soil, for durations which encompassed both acute and chronic exposures. The definitive test durations for the plant species were species specific, ranging from 21 to 61 days to accommodate differences in germination and growth rates of the various species. The earthworm test durations, where LC50 values for adult mortality were estimated, were 14 days. Chronic (e.g., reproduction endpoints) test durations with *Eisenia fetida* and *Enchytraeus albidus* were 70 and 42 days, respectively. The duration of the definitive tests with *Onychiurus folsomi* was 35 days and the measurement endpoints were adult mortality, fecundity, and total number of young produced in each treatment. The results of the whole-soil toxicity tests with this species battery exposed to condensate- and amine-contaminated site soils were compared in terms of species sensitivity, endpoint measurements, and the nature of the contaminants. Generally, it was found that amine-contaminated soil was more toxic to plants and soil arthropods than the condensate-contaminated soil, but less toxic, or as toxic, to earthworms. Springtail adult mortality was equally sensitive an endpoint as fecundity. The sensitivity of test endpoints with plants (shoot length and root length) differed significantly for six of the eight species but there was no pattern to the difference. Of the three earthworm species, *L. terrestris* was consistently the most sensitive species and *E. albidus* the least sensitive. The most sensitive plant species exposed to condensate contamination was alfalfa (shootlength EC50 = 10.8 %), whereas carrot was the most sensitive plant species exposed to amine contamination (root length EC50 = 3.2 %).

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PO-19

BILLIARD[1] S.M., P.V. HODSON[1], N.C. BOLS[2]

RELATIVE POTENCY OF POLYCYCLIC AROMATIC HYDROCARBONS (PAH) FOR INDUCING CYP1A1 IN JUVENILE TROUT (*ONCORHYNCHUS MYKISS*)

Retene (1-methyl-7-isopropyl phenanthrene) is an alkyl-substituted phenanthrene similar to PAHs found in petroleum and products of combustion. We have previously shown that chronic exposure of trout larvae to retene causes dioxin-like toxicity or blue sac disease. Symptoms included prolonged cytochrome P4501A1 (**CYP1A1**) induction, edema, hemorrhaging, and craniofacial abnormalities. Chronic exposure to retene resulted in mortality before swim up and recruitment failure. Results suggest that rapidly metabolized PAH share the same mechanism of toxicity as the more persistent and toxic chlorinated PAH (**CPAH**), i.e. oxidative stress due to prolonged CYP1A1 induction. If this model is correct then the chronic toxicity of PAH to larvae should increase with potency for MFO induction. The rank order of potency for CPAH in causing blue sac disease is the same as the relative potency of these congeners for inducing CYP1A1. Fishspecific toxic equivalency factors (**TEFs**), which relate the potency of individual congeners to dioxin, have been used to assess the risk of CPAH and of CPAH mixtures to fish early life stages. Because PAH are ubiquitous environmental contaminants the risk of toxicity from chronic exposure to PAH may be greater. CYP1A1 induction in juvenile trout was used to derive TEFs for 5 PAH chosen for their induction potency in a rainbow trout liver cell line (RTLW1). The potency of PAH for causing induction was estimated from exposure-response curves as the median effective concentration (EC_{50}) and used to calculate TEFs. With the exception of phenanthrene, all PAH tested induced CYP1A1 activity in juvenile trout and were ranked as follows: benzo[k]fluoranthene > β-naphthoflavone > benzbfluorene > retene. These rankings agree with TEFs derived from RTLW1 cell lines and are currently being used to determine if short-term CYP1A1 induction in juvenile trout can predict chronic toxicity to larvae of PAH and PAH mixtures. This may provide the tools for rapidly assessing the risk of PAH from any source causing recruitment failure of fish.

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PO-20

BOMBARDIER[1] M., N. BERMINGHAM[1]

THE SED-TOX INDEX : A TOXICITY-DIRECTED MANAGEMENT TOOL TO ASSESS AND RANK SEDIMENTS BASED ON THEIR HAZARD. I CONCEPT AND APPLICATION

Several approaches have been proposed to deal with contaminated sediments. Those based on toxicity evaluations have proven particularly useful. The Sediment Toxicity Index (SEDTOX) for the assessment and ranking of (geno)toxic hazards in sediment is presented. Major features include: (i) expression of (geno)toxicity responses on a single scale of measurement (dry weight-based toxic units), (ii) consideration of (multi)specific exposure phases (pore water, organic extract, wet and whole sediments), (iii) application of differential treatments to toxicity data depending on the level of response (lethal or sublethal), and (iv) use of weighting factors to discriminate sediment exposure phases and effect endpoints on the basis of sensitivity. An application of the approach to marine sediments collected from two sectors of the Gulf of St. Lawrence will be demonstrated. Based on the study results, this approach appears to be a promising tool for sediment hazard assessment. Discussion will be focused on the interpretation of the SEDTOX scores, the advantages and disadvantages of the approach, its possible applications and future development perspectives

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PO-21

CALDBICK[1] D.S.

APPROACHES FOR ESTIMATING THE ECOLOGICAL RISK OF A PREDOMINANTLY NATURALLY-OCCURRING SUBSTANCE : CARBON DISULFIDE

Carbon Disulfide (CS_2) is both an important industrial solvent, and a widely distributed natural substance. Emissions from natural sources may be as large as 5 times the proportion released globally from industrial activity. In Canada, people and animals living near sources of industrial emissions may be exposed to higher than natural background concentrations. In order to properly estimate the ecological and human health impacts of anthropogenic concentrations of CS2, careful attention must be paid in the risk assessment to characterizing the exposure due to industrial activities. This will involve identifying all the sources, validating the pathways analysis, quantifying the bioavailabilty, and using field data to distinguish between natural and anthropogenic components of the measured exposure concentration. Once the anthropogenic exposure is characterized as clearly as possible, and the extent of the natural contribution of CS2 to the overall exposure is determined, it may be necessary to establish lower bounds on a threshold concentration for adverse effects, and to evaluate the potential for natural tolerance in receptor organisms. Methods may be simple, such as comparing concentrations of a substance in an exposure medium to distance from a point source or to concentrations in a reference area. In more complex situations, enhanced receptor models or specialized statistical or chemical methods may be used to make the distinction between sources. All these approaches will be discussed using carbon disulfide as the example.

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PO-22

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THE USE OF A WEIGHT-OF-EVIDENCE APPROACH IN AN ECOTOXICOLOGICAL RISK ASSESSMENT OF A CONTAMINATED HARBOUR FACILITY IN MONTREAL

In order to assess the degree and extent of the contamination in the sediments of sector 103 of Montreal Harbour area, an environmental risk assessment was carried out. This evaluation, managed by a consortium of partners representing both industrial and government interests, included three aspects: ecotoxicological, ecological and human health risk assessment . This presentation will focus on the ecotoxicological aspect. Harbour contamination is mainly the result of historical discharges from petroleum and petrochemical refineries, metal refining industries, in addition to municipal wastewater and urban runoff. Contaminants of concern include a variety of PAHs, oil and grease and several metals . A triad approach using chemical and toxicological analyses of surface sediments as well as a benthic survey was conducted at the harbour site and reference sites. Results of the two whole sediment toxicity assays employing the benthic invertebrates *Hyallela azteca* and *Chironomus riparius* were used in conjunction with the relative abundance of the major benthic taxa and the physicochemical properties of the sediments to assess the ecotoxicological risk. Multivariate analysis techniques were used to analyse the data. The overall triad analysis was statistically significant even though the factors causing the toxicity appeared to be different from those affecting the benthic community structure. Overall, the ecotoxicological risk varied from low to severe; the spatial distribution of the triad results was used to identify areas of concern.

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PO-23

EGGLETON[1] M.

L'ÉVALUATION DES SELS DE VOIRIE DANS LE CADRE DE LA LOI CANADIENNE SUR LA PROTECTION DE L'ENVIRONNEMENT

Dans le cadre de la *Loi canadienne sur la protection de l'environnement,* Environnement Canada évalue actuellement le risque environnemental présenté par la substance d'intérêt prioritaire dénommée «sels de voirie». Chaque année, environ 4471 kilotonnes de sels de voirie se retrouvent dans l'environnement au Canada suite à l'entreposage et l'utilisation des ces sels. Cette présentation portera sur l'entrée, le devenir et les effets des sels de voirie dans le milieu terrestre et aquatique. Les critères d'effets seront décrits ainsi que l'approche utilisée pour faire cette évaluation.

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PO-24

GOLD[1] J.R., S.M. RUBY[1], P.D. ANDERSON[1], P. BROUSSEAU[1]

INTEGRATION OF A HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT METHOD (MULTIPLE TOXICITY STUDY OF LAKE AYLMER AREA WELLS)

A risk assessment was conducted on the metal content of well water near Lake Aylmer, located in the Eastern Townships of Quebec, Canada. The study was prompted by the potential health risks to permanent human residents who regularly drank the water. An integrated ecological and human risk assessment method was employed, and multiple and single toxicity issues were examined. Metal content varies among local wells. The metals of the utmost concern, manganese (Mn), cadmium (Cd), arsenic (As) and nickel (Ni) were assessed in detail within 134 wells, including: local exposure, multiple and single toxicity, toxicological risks and risk uncertainties.

Severe toxic effects may result in humans from metal exposure. A hazard quotient (HQ) and index (HI), respectively, was used to assess the single and multiple toxicological risks of metal uptake from the water. There are four significant HQ values for As, ranging from 1.8 to 10.1. The calculated HQ values for Mn, Cd and Ni are not significant. There are five wells with significant multiple toxicity risks, HI values for Mn, Cd, As and Ni combined range from 1.0 to 10.2. Four of the five wells have a significant HI value due to the high As HQ. One of the wells has toxicological risks based only on potential multiple toxicity.

The results show that metal toxicity is a risk in three zones of the study area (containing five wells), and As drinking water standards may require reassessment. Further studies are recommended for the Lake Aylmer region.

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PO-25

LORANGER[1] S., L. HOUDE[2], R. GOUDREAU[1], Y. COURCHESNE[1], B. LANGLET[1]

ÉVALUATION DU RISQUE ÉCOLOGIQUE QUE PRÉSENTE LA COUR D'ENTREPOSAGE DE POTEAUX SITUÉE À RIMOUSKI

La cour d'entreposage de poteaux traités au pentachlorophénol (PCP) d'Hydro-Québec, située à Rimouski, a été choisie comme site expérimental pour appliquer et valider différentes approches d'évaluation du risque écologique (ÉRÉ). Les sols et l'eau souterraine de la cour d'entreposage étaient contaminés au PCP et aux huiles et graisses à des niveaux pouvant dépasser le critère C du MEF. Par conséquent, l'ÉRÉ présentée dans cette étude ne vise qu'à valider sur une base théorique les approches d'évaluation en considérant les conditions initiales de la contamination et d'installation. Le site fut choisi à cause de la présence à proximité de la rivière Rimouski, une rivière à saumon et de la disponibilité des données concernant l'état de contamination du milieu. On y présente un modèle conceptuel décrivant la relation source-devenir-cible-effet. Les récepteurs retenus sont le saumon de l'atlantique, les insectes aquatiques, la marmotte commune, l'écureuil roux et le goéland argenté. L'ingestion est la seule voie retenue pour le calcul de la dose d'exposition des récepteurs. Les valeurs références toxicologiques des espèces ciblées proviennent de la documentation scientifique lorsque disponibles ou calculées selon différentes approches reconnues. Les organismes à risque sont identifiés lorsque le ratio de la dose d'exposition (ou la concentration) et de la valeur référence (méthode du quotient) est supérieur à 1. Des analyses de sensibilité et d'incertitude ont été effectuées selon une approche stochastique à l'aide des simulations de Monte-Carlo. Cette approche probabiliste permet d'intégrer la variabilité des différents paramètres d'entrée lors du calcul du risque.

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PO-26

HANSON[1] M.L.

A PROBABILISTIC ENVIRONMENTAL RISK ASSESSMENT OF TRICHLOROACETIC ACID (TCA) IN CANADIAN TAP WATER

Trichloroacetic acid (TCA) is one of the main halogenation by products of drinking water chlorination. This compound is one of a multitude of chlorinated compounds released from city drains into waterways. Epidemiological studies from various regions, including Ontario, have linked water chlorination with increased risks of bladder cancer in humans. TCA is hepatocarcinogenic to mice and is used as a herbicide in Ontario to control conifers and weed grasses. This compound is phytotoxic and therefore has the potential to impact primary producers, altering ecosystem structure and function. A probabilistic risk assessment was carried out on tap water concentrations of TCA from three water treatment plants in Canada using different means of disinfection. The probabilistic approach allows for the estimation of the magnitude and likelihood of potential impacts to specific groups of organisms and the ecosystem. Using this method it was found that there is no direct risk posed to either fish or invertebrates from tap water inputs of TCA into aquatic ecosystems. There was a 1.7% chance of exceeding the 10th centile of the algae species sensitivity distribution at the Hull, PQ water treatment plant. This facility utilizes a chlorinechlorine system of water disinfection. Overall, the risk to aquatic ecosystems from inputs of TCA via tap water appears to be low, but due to this compound's relatively slow rate of degradation, the risk to enclosed bodies of water may be underestimated.

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PO-27

LORANGER[1] S., L. HOUDE[2], R. SCHETAGNE[3]

FISH INTAKE AND METHYLMERCURY EXPOSURE OF RECREATIONAL AND NATIVE FRESHWATER ANGLERS IN THE UPPER SAINT-MAURICE REGION (QUÉBEC, CANADA)

Hydro-Quebec plans to create two Reservoirs on the upstream section of the Saint-Maurice River with a total area of 250 km², 80% consisting of flooded land. As a result, the methylmercury (MeHg) content in the freshwater fishes will remain higher during a 10 to 20 years period. This may increase the exposure to MeHg of the current fish consumers of this river section: the sport fishermen and the native population. The object of this study is to assess, using a MonteCarlo approach, the fish consumption rate of local fishes by these target groups (adults only) and their MeHg exposure dose. Results show that the average consumption of the fish by sport fishermen was 13.7 g/day (std = 32.7). This value is comparable to the values estimated for other North american freshwater anglers. For the native population, their consumption rate was 10.1 g/day (std = 8.8). On average, this value is 5 to 30 times lower than those estimated for other North American native populations. However, it must be noted that the food habits of this native population is very similar to that of the non native population; less than 30% of the food items comes from traditional sources. Finally, the exposure doses to MeHg in fishes from the Upper Saint-Maurice region of the sport fishermen and of the native population are 145 and 92 ng/kg/day respectively.

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PO-28

TAYLOR[1] K.W.

USE OF MODELS IN THE ENVIRONMENTAL ASSESSMENTS OF PRIORITY SUBSTANCES UNDER THE CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA)

Environmental modelling plays an important role in environmental risk assessment. Dispersion models can be used to predict environmental concentrations of chemicals in the vicinity of point sources. Other models can be used to predict the environmental partitioning of chemicals and the fate of chemicals in the various environmental compartments. In certain circumstances, models may be used to predict the concentration of chemical substances in the various environmental compartments. Models can also be used to predict the effects of chemicals on populations of aquatic organisms.

This poster provides an overview of the use of various models in the environmental assessment of Priority Substances under the *Canadian Environmental Protection Act*.

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CASH[1] K.J., F. MALCOLM CONLY[1], T. BOLLINGER[2]

AVIAN BOTULISM IN PRAIRIE CANADA

At a time when Environment Canada and other agencies are investing millions of dollars in an attempt to increase waterfowl production within the PNR, waterfowl losses attributable to avian botulism has been conservatively estimated at between 100,000 and 1,000,000 per year for each of the last three years. The costs associated with typical disease control measures are considerable but, unfortunately, the effectiveness of these management techniques remains unclear. Although bacterial spores exist in the substrate surrounding many wetlands, disease outbreaks do not occur at every site containing spores and it will not be possible to develop an appropriate management response to avian botulism until there is an improved understanding of the abiotic and biotic factors contributing to outbreaks of the disease. The purpose of this study is to provide an improved understanding of the abiotic as well as the biotic conditions giving rise to botulism outbreaks will serve to identify those wetlands most at risk and allow for the prediction of outbreaks. Specific activities include: (1) Ongoing monitoring of the extent and timing avian mortality resulting from avian botulism at Old Wives Lake (OWL) and a determination of the species most at risk. (2) Quantification of the relationship between botulism outbreaks and such factors as local climate events (e.g. thunder storm, wind tide), water level and water quality at OWL. (3) A test of a predictive model developed by the USGS that makes use of water/sediment chemistry data to assess the risk of botulism outbreak. (4) Participation in a regional research program developed by the Botulism Working Group (appointed by the Prairie Habitat Joint Venture).

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PO-30

MARTEL[1] L., R. CHASSÉ[1], A.M. LAFORTUNE[1], S. BISSON[1], C. THELLEN[1]

PROCÉDURE D'ÉVALUATION DU RISQUE ÉCOTOXICOLOGIQUE POUR LA RÉHABILITATION DES TERRAINS CONTAMINÉS

Pour répondre aux besoins de sa nouvelle *Politique de protection des sols et de réhabilitation des terrains contaminés,* le ministère de l'Environnement et de la Faune du Québec a élaboré une *Procédure d'évaluation du risque écotoxicologique (PÉRÉ).* Cette procédure constitue un document d'encadrement et un guide pour la réalisation d'une évaluation écotoxicologique. Elle préconise une démarche présentant une continuité entre une évaluation du risque écotoxicologique préliminaire et une évaluation du risque écotoxicologique quantitative. Ces approches se distinguent par l'importance relative de l'utilisation de l'information scientifique par rapport au jugement professionnel.

La réalisation d'une évaluation du risque écotoxicologique comprend six phases. La première phase, essentielle à la détermination des routes d'exposition et des réponses écotoxicologiques potentielles des récepteurs biologiques et écologiques, consiste à développer le *modèle conceptuel.* La seconde phase, *outils descriptifs,* a pour but de déterminer les outils qui serviront à vérifier les hypothèses de perturbation. La troisième phase, dont l'objet est de définir les activités qui serviront à mettre en relation les outils descriptifs, consiste à élaborer la *méthodologie d'évaluation.* La quatrième phase, *activités descriptives,* a pour objectif la production de l'information. La cinquième phase, *activités d'évaluation,* vise le traitement des données dans le but de caractériser le risque en fonction des incertitudes s'y rattachant. Finalement, la sixième phase, *activités de communication,* vise à assurer la clarté et la transparence lors de la communication des résultats. Ces phases de réalisation sont précédées d'une étape de *Planification,* essentielle pour la définition des besoins de gestion sur une base compatible avec les activités d'évaluation.

Dans cette présentation, nous porterons une attention aux particularités de l'évaluation du risque écotoxicologique préliminaire.

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PO-31

BROUSSEAU[1] P., Y. MORIN[2], J. PELLERIN[3], D. CYR[4], M. FOURNIER[4]

COMPARAISON DES EFFETS DU MERCURE ET DU CADMIUM SUR LA CAPACITÉ PHAGOCYTAIRE DES HÉMOCYTES DE MYES (*MYA ARENARIA*) SUITE À DES EXPOSITIONS *IN VITRO* ET *IN VIVO*

Le but de cette étude est d'évaluer la sensibilité du système immunitaire de la mye face à certains métaux lourds et ce suite à des expositions *in vitro* et *in vivo*. Pour l'étude *in vitro*, les hémocytes ont été incubés pendant 18 heures avec les chlorures de cadmium ($CdCl_2$), de mercure ($HgCl_2$), de méthyl mercure (CH_3HgCl) et de zinc ($ZnCl_2$), de même que l'argent ($AgNO_3$). Chacun des métaux a été utilisé seul, à des concentrations variant de 10^{-9} M à 10^{3} M. Pour l'étude *in vivo*, les myes ont été exposées pendant 28 jours au $CdCl_2$, au $HgCl_2$ de même qu'au CH_3HgCl à des concentrations variant de 10^{-9} M à 10^{-6} M. La phagocytose a été évaluée en incubant les hémocytes avec des billes fluorescentes nous permettant ainsi d'étudier cette activité par cytométrie de flux. Les résultats obtenus *in vitro* montrent qu'à faible concentration, le mercure et le zinc stimulent le potentiel phagocytaire des hémocytes. À plus fortes concentrations tous les métaux inhibent la phagocytose. En mesurant la concentration inhibant 50% de la phagocytose (CI50), il a été possible d'établir le potentiel immunotoxique des métaux comme suit : $CH_3HgCl > HgCl_2 > AgNO_3 > CdCl_2 > ZnCl_2$. Les résultats obtenus *in vivo*, en cinétique de temps et en cinétique de doses confirment les conclusions obtenues suite aux expositions *in vitro*.

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PO-32

GAUTHIER CLERC[1] S., J. PELLERIN[1] , C. BLAISE[2]

ÉTUDE DIAGNOSTIQUE DE LA CONDITION PHYSIOLOGIQUE ET DU POTENTIEL REPRODUCTEUR DE *MYA ARENARIA* (MOLLUSQUE BIVALVE ENDOBENTHIQUE) EXPOSÉE À LA CONTAMINATION DU FJORD DU SAGUENAY

Les sédiments du fjord du Saguenay présentent une contamination diffuse et multiple (métaux et hydrocarbures aromatiques polycycliques). En 1995, *Mya arenaria* a présenté une condition physiologique perturbée dans le fjord et en particulier à la Baie Eternité, accompagnée de teneurs élevées en métallothionéines. Notre objectif a donc été de dresser un diagnostic de la condition physiologique des myes grâce à différents biomarqueurs liés aux processus des réserves énergétiques (glycogène,; lipides; protéines; glycogène phosphorylase), et au potentiel reproducteur (examen histologique de la gonade). Une première série d'échantillonnages a eu lieu en juin 1996. De mai à octobre 1997, les 3 mêmes sites ont été échantillonnés: le site perturbé de la Baie Eternité, les deux sites contrôle de l'Anse Saint-Etienne et du Moulin à Baude. Nos résultats montrent que les concentrations en glycogène de la gonade des myes sont significativement supérieures au site perturbé par rapport aux deux contrôles de mai à octobre 1997 (excepté en juin) alors que le développement de la gonade présente un retard et une période de maturation plus courte. Les comparaisons interannuelles confirment la persistance d'un retard dans le développement de la gonade au site perturbé. Elles permettent également de mettre en évidence l'influence des fluctuations interannuelles des conditions environnementales sur la condition physiologique des myes. Cette étude met en exergue la pertinence de l'étude du potentiel reproducteur d'une espèce sentinelle notamment pour la population, d'autant plus que l'influence des conditions biotiques et abiotiques du milieu entraînent une variation parfois inattendue de biomarqueurs impliqués dans le coût du maintien de la condition physiologique de l'organisme.

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COUILLARD[1] C.M., M. LEBEUF[1], B. LÉGARÉ[1]

BAISSE DES NIVEAUX DE VITAMINE A PLASMATIQUE CHEZ DES PLIES EXPOSÉES À DES SÉDIMENTS CONTAMINÉS : TOXICITÉ OU MALNUTRITION ?

Des plies canadiennes (*Hippoglossoides platessoides*) ont été exposées en bassin à des sédiments provenant d'un site de l'estuaire du Saint-Laurent contaminé par des biphényles chlorés et des hydrocarbures aromatiques polycycliques. Des plies ont été prélevées après 1 et 10 semaines d'exposition puis, après 1 et 10 semaines d'épuration dans un bassin exempt de contamination. La vitamine A plasmatique et l'éthoxyrésorufine*O*déséthylase hépatique (EROD) servaient d'indicateurs de toxicité. Des indices de condition nutritionnelle incluant le glucose et les protéines plasmatiques, le facteur de condition et le rapport hépatosomatique (RHS) ont aussi été évalués. Aucun des paramètres mesurés ne différait significativement entre les poissons exposés et les témoins sauf la vitamine A, plus basse chez les exposés après une semaine d'exposition (t1). Au temps t1, les niveaux de vitamine A étaient corrélés positivement au niveaux de protéines plasmatiques et au RHS, suggérant un effet de la nutrition. Toutefois, il ne semble pas que la baisse de vitamine A soit liée uniquement à une baisse d'appétit car, pour un même niveau de protéines ou de RHS, les niveaux de vitamine A étaient inférieurs chez les poissons exposés comparés aux témoins. Cette baisse n'était pas associée non plus à une induction de l'activité d'EROD. La baisse de vitamine A observée chez les plies exposées semble donc être le résultat de l'action combinée d'une malnutrition et d'un effet toxique, avec un mécanisme différent de celui conduisant à l'induction d'EROD. Ces résultats montrent l'utilité d'évaluer la condition nutritionnelle des poissons lors d'expériences de toxicité.

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PO-34

DIONNE[1] H., C.M. COUILLARD[2], J.P. CHANUT[1]

LA MAMMOGRAPHIE AU SERVICE DE L'ÉCOTOXICOLOGIE

Les malformations vertébrales sont des indicateurs de la santé de poissons exposés à des contaminants. Les techniques de radiographies traditionnelles (CapMobile, Picker®) n'offrent pas une résolution adéquate pour des poissons de petite taille comme le choquemort (*Fundulus heteroclitus),* largement utilisé en écotoxicologie tant sur le terrain qu'en laboratoire. L'objectif de ce projet est de mettre au point une nouvelle méthode d'investigation, et d'évaluer la sensibilité et la précision des résultats d'examens de la colonne vertébrale sur des radiographies (MX) obtenues à l'aide d'un appareil à mammographies (Senograph, GE,®). Le nombre, le type et le site des malformations vertébrales ont été évalués indépendamment par trois observateurs selon des critères de classification des lésions préétablis sur des MX de choquemorts de trois classes de taille. Pour valider les observations, un sous-échantillon de poissons de la plus petite classe de taille ont été colorés au rouge Alizarin, afin de mettre en évidence le squelette. La sensibilité de la technique MX semblait comparable à celle de la technique de coloration qui est plus laborieuse mais qui a permis de préciser certains critères de diagnostic. De plus, les pourcentages et les types de malformations vertébrales détectés par MX variaient peu entre les observateurs. La technique MX mise au point dans ce projet sera utilisée pour étudier les variations spatiotemporelles des malformations vertébrales chez des choquemorts prélevés dans un estuaire recevant l'effluent d'une usine de pâtes et papiers, et sera applicable à d'autres projets évaluant les effets des contaminants sur le système squelettique des poissons.

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PO-35

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MORPHOLOGICAL DEFORMITIES IN LARVAL *CHIRONOMIDAE* (*DIPTERA*) FROM THE WESTERN BASIN OF LAKE ERIE : A HISTORICAL COMPARISON

Chironomid larvae are an integral part of freshwater benthic communities and are often used to assess environmental quality. Contaminants can eradicate sensitive species or cause sublethal developmental or genotoxic effects. Mouthpart deformities are one indicator of sublethal effects. Historically, western Lake Erie has received contaminants and nutrients from many sources, leading to benthic community impairment. Water quality improved through the 1980's. We examined chironomid larvae collected in benthic surveys by the US EPA in 1982 and 1993 from 38 sites in Lake Erie's western basin. A total of 2,517 chironomids was individually mounted, identified, and examined for morphological deformities (extra or missing teeth in the ligula or mentum). Samples were dominated by *Procladius* and *Coelotanypus*. In 1993, both overall and sites-pecific generic richness were significantly greater than in 1982 (16 genera *vs*. 6 overall, $t = 3.005$; $p < 0.01$), and chironomid density decreased ($t = 8.73$; $p < 0.001$). In 1982, *Procladius* and *Coelotanypus* each displayed significantly elevated overall incidence of deformities (>6%) compared to the baseline level of 1.55% from reference areas of Lake Erie (*G*-statistic goodness of fit test = 67.20, $p < 0.001$). Larvae collected from sites extending from the mouth of the Detroit River showed the greatest incidence of deformities. Between 1982 and 1993, overall incidence of deformities decreased significantly for both *Procladius* and *Coelotanypus*. However, incidences remained elevated (36%) at the mouths of the Detroit and Maumee rivers. Chironomid community and deformity data appear to reflect improving water/sediment quality in western Lake Erie.

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KAREK[1] J., S. ALLEN[1], P.F. DEHN[1]

EFFECTS OF ORGANOCHLORINE INSECTICIDES ON CYTOCHROME P4501A1 AND P4502B ACTIVITIES AND GLUTATHIONE LEVELS IN HUMAN CELLS

The purpose of this study was to examine the effects of organochlorine insecticides on human cytochrome P450 activity and glutathione (GSH) levels. HepG2 (human hepatocellular carcinoma cell line) cells were exposed to appropriate solvent controls (ETOH or toluene) and organochlorine insecticides (1mM o,p'-DDT, 1 mM Kepone, 5 mM Chlordane, 5 mM Endosulfan, 5 mM Methoxychlor, 10 mM Toxaphene) in serum-free, protein-free DMEM for 24 hrs. Cytochrome P4501A1 (EROD) levels were measured using a fluorimetric assay, while cytochrome P4502B (PROD) and GSH levels were measured enzymatically. Tests (alpha 0.05) were performed between the no exposure and solvent control groups and the insecticide and appropriate control. All data was expressed as % of the control. EROD activity was significantly higher (119%, 127%, 127%, 142%, 145% of the controls, respectively) in the DDT, Chlordane, Endosulfan, and Toxaphene exposed cells; while PROD activities were significantly higher (298% & 500% of the controls, respectively) in the Endosulfan and Toxaphene exposed cells. GSH levels were significantly lower (43% & 47% of the controls, respectively) in the Chlordane and Endosulfan exposed cells. Previous studies have shown that the HepG2 cell line responds to dioxins in a manner similar to human cells exposed in primary cultures. These data represent the first report of insecticide stimulation of cytochrome P450 activity in a human cell line and further supports its suitability as an *in vitro* model for aquatic toxicity testing. (work supported by HHMI and Merck/AAAS grants to undergraduate researchers JK & SA).

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MATHIEU[1] A., A. RAHIMTULA[1], J.F. PAYNE[2]

DNA-ADDUCT AND VITAMIN A STUDIES IN BELUGA WHALES FROM THE GULF OF ST.LAWRENCE: EVIDENCE FOR MARKED REDUCTION IN LEVELS OF VITAMIN A

The Gulf of St. Lawrence has a relict population of beluga whales which has come under special attention in recent years because of suggestions of health and survival problems in association with pollution. Cancer has been reported in the population and attention has been drawn to a possible linkage with benzo(a)pyrene (B(a)P) emissions from aluminum smelters. A key step in the mechanism by which B(a)P initiates malignant transformation is through the formation of adducts between DNA and electrophilic metabolites of the carcinogen. Linkage of cancer problems with B(a)P was bolstered by reports of specific B(a)P adducts, incuding very high levels in their DNA. Despite considerable effort we have been unable to confirm that specific B(a)P adducts are commonly found in the DNA of beluga from the Gulf. Further studies were directed towards vitamin A, which plays a critical role in cell differentiation, growth and reproduction and resistance to disease. Levels of vitamin A (measured as retinol by HPLC/ Fluorimetry) were demonstrated to be markedly reduced in liver tissues of beluga from the Gulf in comparison with beluga from the Arctic. Control studies indicated that this reduction was not due to degradation of vitamin A in beached whales, the source of material for the Gulf studies. Recent field studies, by us and others, have demonstrated that fish under chronic conditions of MFO enzyme induction, such as may be mediated by PCB's, dioxins, PAH etc have reduced levels of vitamin A. This may also be occurring in beluga in the Gulf. Given the importance of vitamin A in various aspects of cell growth and function, our results support suggestions by Martineau *et al.*. Sci Total Environ 154 (1994), that the very high concentrations of organohalogens found in beluga may be compromising their health. (Support/assistance by Green Plan Arctic Environmental Strategy, DFO Toxic Chemicals Program, Drs. P. Beland, D Martineau, M. Kingsley, D. Muir and Lyle Lockart and native communities in the Arctic).

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HAMILTON HARBOUR MFO INDUCERS IN CAGED FISH AND SEMIPERMEABLE MEMBRANE DEVICES (SPMDS)

Semipermeable membrane devices (SPMDs), comprised of polyethylene tubes containing a thin film of triolein, can be used to concentrate freely dissolved neutral organic chemicals, such as polyaromatic hydrocarbons (PAHs). SPMDs deployed for 21 days at sites in PAHcontaminated Hamilton Harbour, Ontario, and at a reference site in Lake Ontario, concentrated chemicals that induced mixed function oxygenase (MFO) in fish and rat liver cell lines. Induction was highest at sites near steel processing facilities and ship slips in Windermere Arm, and lower at other Hamilton Harbour sites. Reference Lake Ontario sites were the lowest in potency. The MFOresponses observed in fish and rat liver cells exposed to extracts of SPMDs were paralleled by caged fish. Rainbow trout caged for 721 days at the same sites in Hamilton Harbour and Lake Ontario, showed highest MFO (56 fold induction) at sites near steel processing facilities. Trout hepatic MFO was lower (3fold induction) at other sites on Hamilton Harbour. The fish and cellline MFO responses were very similar, except for one site, where the Burlington sewage treatment plant discharges. Fish MFO induction was a moderate three fold, while cells exposed to SPMD extracts indicated a potent inducer was present. The study shows the utility of SPMDs as concentrators of environmental contaminants and the sensitivity of the cell lines as detectors of MFO. Parallels between fish and SPMD results were good. Linkages of these responses to other measurements in fish (immune toxicity, vitellogenin induction) are presented in related abstracts.

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PO-39

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EXPOSURE ASSESSMENT OF SOIL CONTAMINATED BY ENERGETIC COMPOUNDS USING A SIMPLE WORM BIOMARKER

Energetic compounds (such as TNT) can be toxic and genotoxic to a number of organisms including humans. Because of their recalcitrant properties, contamination of explosives in soil represents a significant international environmental problem. Studies have been carried out in our laboratory to characterize the toxicological effects of TNT, using pure compounds in solution and in spiked soil samples. Simple worm biomarkers, as Neutral Red Retention Time (NRRT) and Total Immune Activity (TIA), reflecting cellular damage or immune response, were applied in laboratory and mesocosms studies to evaluate their potential to detect exposure to TNT and other energetic compounds. Effect assessment of TNT using the earthworms (*Eisenia andrei*) in laboratory was compared to biomarker results. Endpoints measured on earthworms exposed on filter paper included lethality and weight loss. Endpoints for earthworms exposed to artificial soils included lethality, growth, and reproduction (*i.e.* cocoon production, number of juveniles, hatchability, juvenile weight). Mesocosm studies were carried out in the field using laboratory worms (*Eisenia andrei*) and native worms taken from the field ("non contaminated"). Preliminary results showed that NNRT could be an appropriate and simple biomarker for field studies.

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PO-40

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ANOMALIES SUR LES FILETS DE CAPTURE DES LARVES D'*HYDROPSYCHE SLOSSONAE* (*TRICHOPTERA*); UN INDICATEUR POTENTIEL DES EFFETS SOUS-LÉTAUX DU MALATHION (PESTICIDE, ORGANOPHOSPHORÉ)

Les signes des effets sous-létaux causés par des substances toxiques peuvent être observés chez plusieurs espèces aquatiques par la présence de structures difformes et anormales. On remarque ce phénomène chez les larves de Trichoptère du genre *Hydropsyche* où des anomalies sur le filet de capture tissé par ces dernières sont observées en présence de substances nocives. Le but de cette étude a été d'identifier les anomalies observables suite à une contamination des larves d'*Hydropsyche slossonae* à plusieurs concentrations sous-létales de malathion (pesticide, organophosphoré). De plus, nous avons tenté d'établir des relations entre la présence des anomalies et les effets toxiques du malathion, soit l'inhibition de l'acétylcholinesterase. Les larves ont été exposées durant 20 jours à cinq concentrations de malathion (1.0, 0.5, 0.1, 0.05, et 0.01 µg/L) en conditions contrôlées. Les résultats démontrent que des aberrations spécifiques peuvent être imputées aux effets sous-létaux du malathion. L'ensemble des résultats démontre que l'utilisation des anomalies sur les filets de capture des larves d'*Hydropsyche* pourrait représenter un indicateur performant de la toxicité sous-létale des pesticides organophosphorés dans les cours d'eau.

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PO-41

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SILVER UPTAKE AND DEPURATION IN RAINBOW TROUT IN THE PRESENCE AND ABSENCE OF DISSOLVED ORGANIC MATTER (DOM)

Rainbow trout (*Oncorhynchus mykiss*, ~50 g) showed accumulation of silver (Ag) in their gills, plasma, and livers after a 6 h exposure to 0.15 μM Ag in soft water as $AgNO_3$, but showed no ionoregulatory, respiratory, or toxic responses over one week. In contrast, trout exposed to 0.15 μM Ag plus 25 mg C L^{-1} dissolved organic carbon (DOC) accumulated less Ag in their gills, plasma, and livers after the one week exposure. Depuration of accumulated Ag was examined in a preliminary study to determine whether the presence of DOM can act as an additional "sink" for accelerating Ag removal from fish. There was no indication that waterborne DOM increases Ag depuration rates from the gill, plasma, or liver compartments. This experiment is being repeated and gill analysis from the first six days of the experiment indicate that again Ag depuration is not enhanced by the presence of 25 mg C L^{-1} DOC.

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PO-42

COTÉ[1] C., D. MILANI[2], L. TRUDEL[3]

ÉVALUATION DE TROIS ESSAIS DE TOXICITÉ DES SÉDIMENTS À DES SITES MINIERS CANADIENS

Le Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ÉTIMA), élaboré à partir d'un partenariat entre l'industrie minière et le gouvernement, vise à évaluer plusieurs méthodes de surveillance des effets des exploitations minières sur les écosystèmes aquatiques. En 1997, trois essais visant à déterminer la toxicité des sédiments ont été étudiés: survie et reproduction (28 j.) de l'oligochète *Tubifex tubifex*; survie et croissance (14 j) de l'amphipode *Hyalella azteca*; survie et croissance (10 j.) du chironomidé *Chironomus riparius*. Les sédiments ont été récoltés à 63 stations dans trois sites miniers: Westmin Resources (Myra Falls, C.B.), Mattabi (Ignace, Ont.), et Dome (Timmins, Ont.). La capacité relative de ces essais à détecter les effets entre les stations témoins et les stations exposées a été étudiée. L'amphipode *Hyalella* s'est révélé l'indicateur de toxicité le plus sensible. Pour l'un des sites, l'essai avec *Chironomus* a montré une sensibilité équivalente à celui avec *Hyalella*. Dans toutes les stations exposées, les taux de survie de *Tubifex* étaient similaires aux stations témoins et la reproduction n'était affectée qu'à quelques stations. Les sédiments récoltés à l'un des sites n'ont montré aucune évidence de toxicité pour ces trois organismes. La qualité des sédiments (extraction complète, partielle , SEM/AVS) et la structure des communautés d'invertébrés benthiques ont été également déterminées. Les réponses toxicologiques obtenues sont corrélées avec plusieurs de ces variables. Outre les résultats analytiques, des considérations pratiques (coût, durée, commercialisation) ont été examinées. L'ensemble de ces résultats suggère que la notion d'application d'une batterie d'essais (espèces multiples) dans le contexte d'un programme de suivi environnemental pour l'industrie minière n'est peut-être pas essentielle.

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PO-43

GEORGE[1] T.K., K. LIBER[1], K.R. SOLOMON[2], P.K. SIBLEY[2]

TOXICITY OF BINARY AND TERTIARY ORGANOPHOSPHATE INSECTICIDE MIXTURES TO ZOOPLANKTON IN FRESHWATER MICROCOSMS

Mixtures of the organophosphate-insecticides chlorpyrifos, diazinon, and azinphosmethyl were studied in the summers of 1997 and 1998 at a freshwater microcosm facility in Guelph, ON. A binary mixture study investigated mixtures of chlorpyrifos and diazinon, while a tertiary mixture study included all three insecticides. Mixture toxicity was assessed using both inhibition of acetylcholinesterase activity and changes in zooplankton population abundances. Initially, a regression study was performed with diazinon and chlorpyrifos to establish toxicity thresholds for zooplankton populations. Selected concentrations were based on multiples of the 90th centile of measured organophosphate concentrations in surface waters. Results from the regression study indicated that a chlorpyrifos toxic equivalent concentration of 0.40 - 0.45 µg/L was suitable to assess binary and tertiary mixture toxicity to zooplankton in an ANOVA study (each mixture replicated three times). Each mixture was theoretically of equal toxicity and dominated by one pesticide (≥80%); the remaining pesticides were apportioned equally (~10%). To achieve equal toxicity, toxic equivalents were used and all components of the mixtures were standardized to the most toxic component, chlorpyrifos. Both binary and tertiary mixtures exhibited acute toxicity to Cladocera and Copepoda, while Rotifera were unaffected. Acetylcholinesterase activity measurements for selected species of Cladocera correlated with changes in population abundance. Overall, the selected endpoints showed that the toxicity of the organophosphate mixtures of different proportions, but similar toxic equivalence, was approximately equal.

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PO-44

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GROWTH AND HEALTH OF *MYRIOPHYLLUM SPICATUM* AND *M. SIBIRICUM* EXPOSED TO TRICHLOROACETIC ACID IN AQUATIC MICROCOSMS

Trichloroacetic acid (TCA) has been detected in rain, snow, and river samples from across Canada. It is a registered herbicide for use in Ontario and has been used in Australia to control *Myriophyllum spicatum*. TCA poses a potential risk to aquatic communities, specifically algae and plants. A study to assess this risk was conducted in the summer of 1998 at the University of Guelph Microcosm Facility. The experiment involved exposing three replicate 12 m3 aquatic microcosms to 50, 500, 3000, and 10000 g/L of TCA for 35 days in an one-way ANOVA design. Each microcosm was stocked with 14 individual *M. spicatum* and *M. sibiricum* 5 cm in length. They were sampled at regular intervals and assessed for the somatic endpoints of plant length, root growth, number of nodes and wet/dry weight and the biochemical endpoints of chlorophyll a/b and carotenoid content, as well as lipid peroxidation and citric acid levels. Results indicate that there were no significant differences in any of the somatic endpoints or chlorophyll a/b and carotenoid content. Lipid peroxidation and citric acid levels are currently being evaluated. The risk TCA poses to these macrophytes is minimal at the highest concentrations and non-existent at environmentally relevant concentrations.

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PO-45

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ECOLOGICAL RESPONSES OF THE MAYFLY *BAETIS TRICAUDATUS* TO CADMIUM BOUND TO FOOD SURFACES

Effects of contaminants surface-bound to food materials are often ignored in toxicity tests. Most tests are designed to measure aqueous toxicity only. It was hypothesised that *Baetis tricaudatus* nymphs would be able to detect cadmium surface-bound to *Navicula* mats. They would either graze at a lower rate or not at all. When given a choice between cadmium coated or uncoated mats, nymphs would show a preference for uncoated mats. Reduced growth during long-term exposure to coated mats, could either result from the reduction of feeding opportunities or from the ingestion of cadmium (toxicity).

Range-finding tests were conducted to estimate the acute toxicity and growth toxcity of cadmium to *B. tricaudatus* and *Navicula*, respectively. The amount surface bound to a mat submerged for 20 minutes in 100µg/L of cadmium, was determined (8ng/mat). Mats exposed in the same way were fed to *B. tricaudatus* nymphs in two short-term feeding experiments (50 and 150 minutes) and one long-term feeding experiment (11 days), to test the aforementioned hypotheses.

The preliminary results suggest that *B. tricaudatus* nymphs cannot detect cadmium bound to diatom mat surfaces. Nymphs grazed on them and did not avoid them. Long-term grazing on cadmium coated mats led to reduced grazing and growth rates, implying that the affected populations may experience reduced fitness.

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PO-46

MARWOOD[1] C.A., K.R. SOLOMON[1], R.E. SMITH[2], B.M. GREENBERG[2]

INHIBITION OF PHOTOSYNTHESIS IN NATURAL ASSEMBLAGES OF LAKE ERIE PHYTOPLANKTON EXPOSED TO POLYCYCLIC AROMATIC HYDROCARBONS IN SUNLIGHT

Recently, there has been a trend towards less turbid water and greater light penetration in Lake Erie. Phototoxicity from sediment-bound and aqueous PAHs is expected to increase with increased light penetration. In this study, natural assemblages of phytoplankton were collected in water samples from the western and central basins of Lake Erie. Anthracene or the photoproduct 1,2-dihydroanthraquinone were added to water samples at concentrations of 0.2 to 2 µg/L. Samples were incubated in darkness or in 50% sunlight to simulate the light environment in the photic zone. Photosynthetic efficiency was measured from filtered phytoplankton immediately after incubation using a pulse-amplitude modulated (PAM) chlorophyll fluorometer. Phytoplankton exposed to PAHs in the dark demonstrated chlorophyll fluorescence values similar to controls. However, exposure to anthracene or 1,2-dihydroanthraquinone in sunlight reduced PSII photosynthetic efficiency and quantum yield in a concentrationdependent manner, indicating strong inhibition of photosynthesis. Anthracene inhibited photosynthesis at lower concentrations than its photoproduct 1,2-dihydroanthraquinone, consistent with different modes of action for these two PAHs. Toxicity was comparable for phytoplankton populations sampled from several different locations on the lake. These results demonstrate that phytoplankton are subject to phototoxicity from low concentrations of intact and photomodified PAHs currently found in Lake Erie.

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PO-47

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TOXICITY OF HIGHWAY RUNOFF IN SOUTHERN ONTARIO

Highway runoff has been identified as an important contributor of nonpoint source pollution. Highway discharges contain a broad variety of compounds, including heavy metals, chlorides and polycyclic aromatic hydrocarbons (PAHs). Many of these substances are known to be toxic to freshwater organisms. The aim of the present study was to investigate the effect of the traffic density and composition on the contaminant levels in highway runoff and on the associated toxicity. Seasonal aspects of runoff toxicity were also evaluated. Samples from three sites (high, intermediate and low traffic density) were collected. A battery of bioassays was used to assess the degree of runoff toxicity and chemical analyses were carried out to measure the concentrations of chlorides, metals (including heavy metals), PAHs and nutrients. Variations in toxic responses were observed both seasonally and within runoff events. The runoff samples containing high concentrations of road salts from winter maintenance were acutely toxic to *Daphnia magna*. The results of the submitochondrial (SMP) toxicity tests were consistent with the *D. magna* acute toxicity tests. The results of nematode tests indicate moderate to severe toxicity of road sediments. Within a single event, a sharp decline in *Ceriodaphnia dubia* toxicity to runoff over time confirmed that the "first flush" was the most toxic. A significant Mixed Function Oxidase (MFO) induction in rainbow trout was observed, which was consistent with the high concentrations of PAHs in road sediments.

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PO-48

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THE RELATIVE SENSITIVITY OF FOUR BENTHIC INVERTEBRATES TO CADMIUM, COPPER AND NICKEL IN SPIKED SEDIMENTS AND CONTAMINATED FIELD SEDIMENTS

Four species of benthic invertebrates are employed by Environment Canada in sediment toxicity tests. The relative sensitivity of these species to cadmium, nickel and copper spiked sediments is being assessed. Additionally, the sensitivity of these benthic invertebrates to field sediments from Collingwood Harbour, contaminated primarily with copper, is also being examined. *Hyalella azteca* is the most sensitive species to all metals in spiked sediments when looking at survival, with LC50's ranging from 19- 41 ppm, followed by *Chironomus riparius* (30- 311 ppm), *Hexagenia spp.* (< 100-707), and *Tubifex tubifex* (224- 566 ppm). *H. azteca* is also the most sensitive species when looking at growth in spiked sediments, with IC25's ranging from 3.7- 25 ppm, followed by *Hexagenia spp.*, and *C. riparius*. *T. tubifex* is the least sensitive organism in the spiked metal tests, with reproductive endpoints (number of cocoons per adult; number of young per adult; percent cocoons hatched) ranging from 162 to 625 ppm. Results from Collingwood Harbour, with bulk sediment copper concentrations ranging from 117 to 5150 µg/g copper, however indicate *T. tubifex* to be the most sensitive species. Reductions in reproduction were significant at a number of sites, while toxicity was not evident in the tests with the other three species. These results point to the importance of determining the relative sensitivities of test species in order to better evaluate the source of toxicity in sediments, the bioavailability of toxicants, and identifying the possibility of other unknown contaminant(s) present in sediments.

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ANALYSIS OF «WET-LANDSCAPE» SURFACE WATER FRACTIONS USING THE MEDAKA EMBRYO-TOXICITY BIOASSAY

Syncrude's «wetland-scape» method of waste disposal involves capping fine-tailings with a layer of surface water. Experimental pits of different ages and fine-tailings/natural water compositions were constructed to assess the self-sustaining biological potential of this waste disposal method. Preliminary experiments suggest a higher incidence of mortality and deformity in Japanese medaka embryos incubated in pit waters containing elevated concentrations of naphthenates. Naphthenic acids, naturally occurring surfactants in bitumen, are released into water as sodium salts during oil-sand extraction processes and have been identified as an acutely toxic component of fine-tailings. Another study on adult perch stocked in the demonstration pit indicated the presence of PAHs in the fish bile at biologically relevant concentrations. The purpose of this study was to determine the causative agent(s) of the fish embryo toxicity and at what concentrations are there chronic effects. Water extracts from the pits were fractionated into acid (containing naphthenates) and base-neutral (containing PAHs) components and tested using the Japanese Medaka bioassay. Eggs at the blastodisc stage were exposed to serial dilutions of the extracts. Endpoints measured were presence of deformity, hatch success, swim-bladder inflation, length at hatch and time to mortality. Toxic concentrations of naphthenates were determined from the acid fraction exposures for different aged pits. Some base-neutral fractions were toxic at extract concentrations higher than those measured in the environment. HPLC analysis showed PAHs were present at concentrations in the ppb and ppt range, indicating PAHs are not directly responsible for the observed toxicity to the embryos.

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PO-50

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NICKEL AND MOLYBDENUM TOXICITY TO FRESHWATER FISH

The toxicity of mine effluent containing metals to freshwater fish is usually characterized using standard toxicity test fish species such as rainbow trout (*Oncorynchus mykiss*) or fathead minnows (*Pimephales promelas*). However, these fish species often do not inhabit lakes receiving mine effluents. This leads to questions concerning the ecological relevance of conducting toxicity evaluations using non-indigenous fish. Nickel and molybdenum are two metals of concern to the uranium mining community in Saskatchewan. The purpose of the current study was to determine the toxicity of nickel and molybdenum to northern pike (*Esox lucius*) and white suckers (*Catostomus commersoni*) and compare this toxicity to the standard test species. Pike and white suckers are common in lakes surrounding uranium mining operations in northern Saskatchewan. Pike and sukcers were captured and stripped of gametes. Eggs were fertilized in the field and transported back to the laboratory in Saskatoon. Toxicity tests were conducted to determine egg hatchability and teratogenesis using environmentallyrelevant concentrations of nickel and molybdenum. Fish larvae hatched under laboratory conditions were exposed to both acute and subchronic nickel and molybdenum exposures scenarios to determine 96h- LC_{50}, long-term survival and growth. Results were compared to similar toxicity test results from fathead minnow and rainbow trout in an attempt to address the question of interspecies toxicity differences.

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PO-51

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ACUTE AND SUBLETHAL TOXICITY OF THALLIUM TO AQUATIC ORGANISMS

Acute and sublethal toxicity studies were carried out using the following species: *Selenastrum capricornutum, Ceriodaphnia dubia, Daphnia magna,* and *rainbow trout* to generate threshold toxicity values for aquatic life to assist the assessment of potential effect of thallium discharge on the Columbia River ecosystem in British Columbia. Toxicity values indicated that the algae, *Selenastrum capricornutum* was the most sensitive with an IC25 value of 0.09mg/L thallium. The other test species had a range of response to thallium concentrations: Rainbow trout 96h- LC50 (4.27 mg/L), *Daphnia magna* 48h- LC50 (2.01 mg/L), *Ceriodaphnia dubia* 7 day reproduction IC25 (0.10 mg/L) and *Ceriodaphnia dubia* 7 day LC50 (0.37 mg/L).

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PO-52

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REDUCING UNCERTAINTY IN RISK ASSESSMENTS BY MEASURING EFFECTS UNDER REALISTIC EXPOSURE CONDITIONS : A COMPARISON OF LABORATORY AND FIELD APPROACHES

Recent assessments of tributyltin (TBT) and chlorinated hydrocarbons suggest that laboratory bioassays may not adequately characterize exposure or effects for bioaccumulative chemicals of concern. These chemicals generally take longer to reach equilibrium and have there most profound effects only after uptake a receptors of concern. Most traditional laboratory bioassays do not have a sufficient exposure period to adequately represent steady state conditions in the real world environment for bioaccumulative chemicals of concern. Examples will be provided from an industrial area In Puget Sound and an Alaskan pulp mill to show that laboratory bioassays may not have adequately characterized either exposure or effects. The examples demonstrate that: (1) Chemical equilibrium should be considered when determining test duration and standardizing protocols; (2) Exposure and effects endpoints should be combined in laboratory toxicity and bioaccumulation tests, and (3) Tissue chemistry should be considered an integral part of ecological risk assessments. Using manipulative field experiments and the exposure-dose-response triad can reduce that uncertainty.

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PO-53

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EVALUATION OF CHEMICAL, BIOCHEMICAL AND TISSUE METHODS FOR MONITORING EFFECTS OF EFFLUENTS FROM METAL MINES ON FISH

As part of the AETE program, currently available methods for assessing effects of effluents from metal mines on fish at sub-organism-levels of biological organization were reviewed and evaluated for their potential use in monitoring programs. These methods involve observations on chemical -(i.e., metal concentrations in tissues), biochemical, and tissue-level structures and function (excluding metallothionein and histopathological conditions). Because impairment of processes at these levels underlie toxicological responses at the whole organism-, population- and community-levels, the detection of physiological impairment could serve as an early indication of adverse effects and allow corrective action before impacts are observed at higher levels. Chemical, biochemical and tissue methods were evaluated based on (a) their relationships to ecologically important (higher level) effects, (b) their responsiveness to mining-related environmental disturbances, and (c) their ease of application in monitoring programs. Most of the methods evaluated were considered currently unsuitable for monitoring effects of metal mines because of their lack of specificity in their response to metal contaminants, and/or difficulties in establishing unambiguous linkages to population-level effects in field studies. The measurement of metal concentrations in tissues (as a means of indicating exposure to disturbance due to mining) and the examination of biochemical indicators of growth are the strongest candidates for inclusion in monitoring programs.

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PO-54

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EVALUATION OF FISH POPULATION AND COMMUNITY SURVEYS FOR MONITORING ENVIRONMENTAL EFFECTS OF METAL MINES

The usefulness of population and communitylevel fish variables and surveys for monitoring effects of metal mines was reviewed for the AETE program. In adult fish surveys (AFS), populationlevel effects are indirectly assessed using growth, reproduction, and age structure. Direct population-level surveys measure absolute or relative abundances of single species populations; fish community surveys (FCS) measure relative abundances of several to many species. Population and communitylevel variables are ecologically more relevant, and less costly to measure, than lower-level variables. Population and community variables respond to physical and other stressors as well as to metal contamination and low pH. This lack of specificity may be a disadvantage where chemical contamination and acidification are the primary concerns, but not where physical alteration from tailings discharge, placer mining and road construction are primary concerns. Field collection costs are higher for direct population assessments and FCS than for AFS because more fish and sample sites are required. Effects are also likely to be detected sooner in an AFS. Therefore, an indirect AFS-type assessment of effects on fish populations was recommended for environmental effects monitoring (EEM) at most mine sites. However, alternatives to an AFS should be included in any national EEM program for the mining industry.

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PO-55

PAINE[1] M.

APPLYING AND IMPROVING BEFOREAFTER-CONTROL-IMPACT (BACI) DESIGNS IN ENVIRONMENTAL EFFECTS MONITORING (EEM) PROGRAMS

BACI designs are recommended for EEM because they provide both spatial and temporal controls. Control and Impact sites are sampled both Before and After some stress occurs or begins. In BACIP designs (P = Paired sites), the same Control and Impact sites are re-sampled at each of *t* randomly selected times within the Before and After periods. In repeated measures (RM) BACI designs, the same *I* randomly selected locations within Control and Impact sites are re-sampled each sample time. The sample times can be randomly selected or evenly spaced; the latter is logistically and statistically more convenient. RM BACI designs will usually be superior to BACIP designs, because random sampling is easier to implement in space than in time. In all BACI designs, impacts can be confounded with natural spatial-temporal changes or variance. Natural spatial-temporal variance can be surprisingly large for shortlived freshwater invertebrates and marine fish larvae. Risks of confounding can be reduced by scaling sampling frequency to the generation time of target organisms or by using larger, longer-lived organisms. BACI designs can also be improved by sampling randomly selected multiple reference or Control sites, or by sampling along a gradient of exposure. Basic BACI designs, modifications, and potential problems will be illustrated using case histories.

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PO-56

SAINT-CYR[1] L., A. CATTANEO[2], R. CHASSÉ[3], C.G.J. FRAIKIN[4]

MACROPHYTES, PHYTOPLANKTON AND PERIPHYTON AS BIOMONITORS TO ASSESS THE IMPACTS OF MINE EFFLUENTS ON THE AQUATIC ENVIRONMENT

We assessed for the Aquatic Effect Technology Evaluation Program (Natural Resources Canada) the potential use of macrophytes, phytoplankton and periphyton to monitor the impacts of mine effluents on the aquatic environment. We evaluated and compared both established methods and new approaches. Macrophytes have an interesting potential as biomonitoring organisms. Plant communities respond to mine effluents by changes in species composition, metal accumulation in their tissues and synthesis of biochemical indicators. In phytoplankton, methods based on biomass changes and species shifts have so far been applied to monitor mine sites. Other approaches, as community canonical analysis, size distribution, diatom deformities, induced tolerance, promise to be more powerful than the traditional ones. The use of periphyton in impact studies has been partly hindered by its complexity and heterogeneity. However, this community, easy to sample and not mobile, integrates well the effects of environmental variables and warrant further effort in methodological standardization. All these approaches need field testing to verify their applicability and generality. The potentials and limitations of these methods, especially in view of their integration into a cost effective monitoring program, are discussed.

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PO-57

STEWART[1] A.R., D.F. MALLEY[1], J. PAPINEAU[2]

TECHNICAL EVALUATION OF MOLLUSCS AS A BIOMONITORING TOOL FOR THE CANADIAN MINING INDUSTRY

As part of the Aquatic Effects Technology Evaluation Program (AETE) molluscs were evaluated as potential biomonitoring organisms for the Canadian Mining Industry. Laboratory and field data were consulted and a framework for the use of molluscs in a monitoring program was developed. Molluscs are a diverse taxanomic group including bivalves and gastropods. Several species of molluscs were found to meet the criteria for a good biomonitor such as being relatively nonmobile, abundant and widely distributed, large enough to provide sufficient tissue for metal analysis, tolerant of wide ranges of contaminant concentrations and strong accumulators of metals (Cd, Cu, Zn, Pb, Ni, Hg, As, Ag and Cr). The use of molluscs is limited to environments with pH above 4.7 and calcium concentrations below 2 mg/L. The relationship between mollusc tissue metal concentrations and ambient metal concentrations is influenced by a number of biological, physical and chemical parameters that need to be taken into account when designing field studies and interpreting results. Transplanted and indigenous molluscs are recommended as indicators of exposure to metals and could be used to monitor spatial and temporal changes in bioavailable metals resulting from mining activities and to determine the effectiveness of remedial measures. Metal-induced effects in molluscs such as changes in growth, or metallothionein concentrations are not well established and require further field validation.

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PO-58

GOUDEY[1] S.E., D.A. BIRKHOLZ[2], J. WITTEMAN[3], C. ROUSSEAUX[4], J. ZELIKOFF[5]

AQUATIC TOXICITY ASSOCIATED WITH DIAMOND MINING 2

HydroQual Laboratories was commissioned to perform acute and chronic toxicity testing including : microbes (bacterial luminescence), plants (*Selenastrum capricornutum*), invertebrates, (*Daphnia magna*, *Ceriodaphnia dubia*) and fish (*Oncorhynchus mykiss*) on kimberlite solutions. HydroQual Laboratories was also commisioned with designing flow through exposure experiments to kimberlite solutions using mature rainbow trout for up to thirty days. Since the aquatic receiving environment in Northern Canada consists of very soft water and stable kimberlite solutions are difficult to prepare, HydroQual had to develop some innovative testing procedures to deal with these realities. This presentation outlines the procedures used in order to obtain aquatic toxicilogical data for kimberlite relevant to the Northern aquatic receiving environment. Results obtained for the aquatic toxicity program will be presented and discussed.

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[2] EnviroTest Laboratories, Edmonton, AB
[3] BHP Diamonds Inc., BHP World Minerals, Yellowknife, N.W.T
[4] Global Tox, Ottawa, ON
[5] New York University Medical Center, Tuxedo, NY

PO-59

BIRKHLOZ[1] D.A., J. WITTEMAN[2], S.E. GOUDEY[3], C. ROUSSEAUX[4], J. ZELIKOFF[5]

AQUATIC TOXICITY ASSOCIATED WITH DIAMOND MINING 3

EnviroTest Laboratories was commisioned by BHP Diamonds to design, implement and manage a toxicity testing program to address the concerns levied by regulators and the general public. Part of the investigation included subjecting mature fish, rainbow trout, *Oncorhynchus mykiss*, to 50 and 500 mg/L of kimberlite ore solutions in a flowthrough bioassay for up to 30 days. Following exposure, fish were sacrificed after 15 and 30 days and subjected to external and internal examination. Blood samples were taken and analyzed for cortisol, testosterone and estradiol. Liver, kidney and gill tissue were excised and analyzed for metallothionein induction. Metals analyses were performed on liver, kidney, gill, muscle and bile. Chemical and biomarker data obtained will be presented and discussed.

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[2] BHP Diamonds Inc., BHP World Minerals, Yellowknife, N.W.T
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[5] New York University Medical Center, Tuxedo, NY

PO-60

ROUSSEAUX[1] C., D.A. BIRKHOLZ[2], J. WITTEMAN[3], S.E. GOUDEY[4], J. ZELIKOFF[5]

AQUATIC TOXICITY ASSOCIATED WITH DIAMOND MINING 4

Global Tox was commisioned with the task of histopathological examination of tisues (gill, liver and kidney) obtained from fish exposed to kimberlite solutions (50 and 500 mg/L) and control water for 30 days. This presentation provides details of our findings.

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[2] EnviroTest Laboratories, Edmonton, AB
[3] BHP Diamonds Inc., BHP World Minerals, Yellowknife, N.W.T
[4] HydroQual Laboratories Ltd., Calgary, AB.
[5] New York University Medical Center, Tuxedo, NY

PO-61

ZELIKOFF[1] J., D.A. BIRKHLOZ[2], C. ROUSSEAUX[3], J. WITTEMAN[4], S.E. GOUDEY[5]

AQUATIC TOXICITY ASSOCIATED WITH DIAMOND MINING 5

New York University Medical Center was commisioned with the task of ascertaining immunocompetence of fish exposed to kimberlite solutions (50- and 500- mg/L) for up to 30 days. Kidney, spleen and whole blood were tested for innate immunity (intracellular superoxide and phagocytosis), humoralmediated immunity (plasma Ig and B-lymphocyte proliferation), cellmediated immunity (T-lymphocyte proliferation) and immunopathology (hermatocrit, leukocrit and blood cell differentials). Data obtained will be presented and discussed.

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[2] EnviroTest Laboratories, Edmonton, AB
[3] BHP Diamonds Inc., BHP World Minerals, Yellowknife, N.W.T
[4] HydroQual Laboratories Ltd., Calgary, AB
[5] Global Tox, Ottawa, ON

PO-62

MONETTE[1] A.E.

EVALUATING MEASURES OF SUB-LETHAL STRESS IN *MYTILUS* SPP. FOR CONTAMINANT MONITORING IN THE BAY OF FUNDY/GULF OF MAINE ECOSYSTEM

The Gulf of Maine Council on the Marine Environment's Gulfwatch program currently uses *Mytilus* spp. body burdens and tissue concentrations of anthropogenically-derived contaminants as indicators of marine habitat exposure to chlorinated pesticides, polynuclear aromatic hydrocarbons, polychlorinated biphenyls and trace metals. Such data from mussels are intended to reflect the ambient contaminant concentrations and the overall health of the Bay of Fundy/Gulf of Maine ecosystem in this context. In addition to contaminant measures, Gulfwatch also employs biological endpoints or measures such as mussel shell growth, condition index and gonad index. To enhance this biomonitoring program and better demonstrate an ecotoxicological connection, practical sub-lethal measures of stress in *Mytilus* could be added to the current monitoring approach. This project evaluates cytological biomarkers (e.g., gamete viability, lysosomal membrane stability, haematocyte condition) and physiological biomarkers (e.g., filtration rate, embryo-larval development) in terms of their potential relevance, ease of use by community group volunteers, and practicality within the Gulfwatch monitoring framework. By expanding the Gulfwatch monitoring approach with additional endpoints, an assessment of exposure (tissue burdens and concentrations) and effects (measures of sub-lethal stress) could be achieved and used in risk assessment and risk management within the Bay of Fundy system. This will contribute to a broader goal of maintaining and enhancing the health of the coastal zone.

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PO-63

LEBEUF[1] M., K.E. BERNT[2], M. HAMMILL[1], L. MEASURES[1], M. NOËL[1], S. TROTTIER[1]

TCPM AND TCPME IN MARINE MAMMALS FROM THE ESTUARY AND GULF OF ST. LAWRENCE

Tris (4 chlorophenyl) methanol (TCPM) and *Tris* (4 chlorophenyl) methane (TCPMe) are among the most recently reported persistent organic pollutants (POPs) in environmental samples. These compounds are believed to originate from a variety of sources including agrochemicals such as DDT and compounds used in the production of synthetic dyes. There is presently little information available on the levels and the distribution of these compounds in the Canadian marine environment. TCPM and TCPMe levels in blubber samples of marine mammals from the Estuary and Gulf of St. Lawrence were determined by gas chromatography/(mass spectrometry)[2] (GC/MS/MS) Average concentrations of TCPM and its presumed precursor TCPMe in harp seals (*Phoca groenlandica*), harbour seals (*Phoca vitulina*), hooded seals (*Cystophora cristata*), grey seals (*Halichoerus grypus*), and beluga whales (*Delphinapterus leucas*) vary from 11.7 to 28.4 ng/g wet wt and from 0.7 to 11.6 ng/g wet wt, respectively. Despite these rather narrow ranges of concentrations, the relative proportions of TCPMe and TCPM levels were quite different among seal and whale species, possibly due to their differing metabolic capabilities. As a result, TCPMe levels were higher in blubber from beluga whales than in grey seals but grey seals showed higher TCPM levels.

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[2] Department of Biology, University of Waterloo, ON

PO-64

LEE[1] K., G.D. WOHLGESCHAFFEN[1], G.H. TREMBLAY[1], J.H. VANDERMEULEN[2], D.C. MOSSMAN[2], K.G. DOE[3], P.M. JACKMAN[3], R.C. PRINCE[4], R.M. GARRETT[4], C.E. HAITH[4]

PERSISTENCE, BIODEGRADATION AND BIOLOGICAL IMPACT OF BUNKER C RESIDUES IN BLACK DUCK COVE, NOVA SCOTIA

In 1970, approximately 2,045 m^3 of Bunker C crude oil impacted 300 km of Nova Scotia's coastline following the grounding of the tanker *Arrow*. Only 10% of the contaminated shoreline was subjected to cleanup, the remainder was left to degrade naturally. In 1993 and 1997, samples of sediment and interstitial water were collected at Black Duck Cove, a representative untreated site where residual oil from the *Arrow* spill was clearly evident. Detailed chemical analyses showed that the residual Bunker C oil at this site has undergone substantial biodegradation. The significance of long-term natural attenuation processes (no treatment) on the reduction of toxicity within sediments and interstitial waters was evaluated. The toxicity test battery included: measurement of changes in hepatic CYP1A protein levels and mixed function oxygenase (MFO) induction in winter flounder (*Pleuronectes americanus*), the Amphipod (*Eohaustorius estuarius*) Survival Test, the Microtox™ (*Vibrio fisheri*) Solid-Phase Test, the Echinoid (*Lytechinus pictus*) Fertilization Test, and the Microtox™ (*Vibrio fisheri*) 100% Test. Results ranged from toxic responses to sediments (e.g., Amphipod Survival Test) to that of no significant effect observed for interstitial waters (e.g., Echinoid Fertilization Test). As a result of natural recovery processes over a >20year period, the toxicity of the residual oil has been reduced and there is substantial evidence of habitat recovery.

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PO-65

COUILLARD[1] C.M., P. NELLIS[1]

IDENTIFIER ET LOCALISER LES SOURCES DE COMPOSÉS CHLORÉS EN MILIEU ESTUARIEN À L'AIDE DE POISSONS DE PETITE TAILLE, LES CHOQUEMORTS (*FUNDULUS HETEROCLITUS*)

Les niveaux de dioxines et furannes (DF), de chlorophénols (CP), de biphényles polychlorés (BPC) et de pesticides chlorés ont été mesurés dans les tissus de choquemorts. Ces poissons ont été capturés dans l'estuaire de la Miramichi, recevant l'effluent d'une usine de pâtes et papiers avec blanchiment au chlore, et dans un estuaire témoin, l'estuaire de la Bouctouche. Des analyses multivariées ont été utilisées pour identifier la nature des sources de contamination et pour les situer. Le patron de distribution du mirex, contaminant provenant d'une source aérienne distante, a été comparé à celui des différents groupes de contaminants. Des sources de DF, CP, BPC et DDT ont été localisées au site amont de la Miramichi (M1). De plus, la comparaison des profils de congénères entre les sites a indiqué que la contamination des poissons en DF et en CP au site M1 provenait non seulement de l'usine de pâtes et papiers mais aussi d'un ancien site de traitement du bois, source de pentachlorophénol. Les patrons et les niveaux de contaminants dans les choquemorts différaient entre les sites d'un même estuaire indiquant que les poissons migraient peu d'un site à l'autre. Grâce à sa sédentarité et sa facilité de capture, le choquemort permet de décrire les patrons de contamination du biota en milieu estuarien sur une petite échelle géographique.

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PO-66

BRETON[1] R.L.

CATEGORIZATION AND SCREENING OF THE DOMESTIC SUBSTANCES LIST (DSL): STATUS AND PROCESS

In Canada, substances on the Domestic Substances List (DSL) are assessed by two federal government departments, Environment Canada and Health Canada, to determine if they pose a risk to the environment and to human health. The DSL identifies about 22 000 substances, between January 1, 1984 and December 31, 1986, that were in Canadian commerce, used for manufacturing purposes, or manufactured in or imported into Canada in a quantity of not less than 100 kg in any calendar year. This presentation will discuss the environmental assessment of these substances. The revised *Canadian Environmental Protection Act* (CEPA) (pending promulgation) states that these assessments initially involve the "categorization" of substances based on their persistence, bioaccumulation potential and inherently toxic properties. If a given substance is determined to be persistent or bioaccumulative, and inherently toxic based on categorization criteria, then that substance proceeds to a screening level risk assessment to determine if it poses a risk to the Canadian environment. This presentation will provide an update on the major issues that need to be addressed and the methods and tools that are being developed to address the issues.

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PO-67

GAGNON[1] C., R.A KENT[1], E.S. ROBERTS[1], P.A. CHAMBERS[2], M.N. CHARLTON[3]

NUTRIENTS AND THEIR IMPACTS ON THE CANADIAN ENVIRONMENT A NATIONAL ASSESSMENT

The issue of excess nutrients entering the environment from human activities has long been recognized as a significant contributor to environmental degradation, particularly in aquatic ecosystems. Nitrogen and phosphorus nutrien-trelated impacts (e.g., eutrophication) from agricultural practices, wastewater and industrial effluents are well established in Canada and throughout the world. To date, the sole federal regulatory response under the Canadian Environmental Protection Act relate to a control of phosphorus in laundry detergents. As a result, the Government of Canada has recently commissioned a national assessment to identify the presence and extent of environmental impacts (aquatic and terrestrial) caused by excess nutrients in Canada. The first of its kind, the assessment will attempt to determine whether nutrients as a class, and whether certain nutrients, or nutrientcontaining products are problematic and whether those effects are limited to one component of the environment, such as water, or the entire ecosystem, including wildlife. A review of existing regulatory mechanisms for nutrients accross Canada is also underway.

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[3] National Water Research Institute, Environment Canada, Burlington, ON

PO-68

KENT[1] R.A., P.Y. CAUX[1], R. ALLAN[2], R. POST[3], J. PARKS[4].

A CANA-DAWIDE GIS ANALYSIS OF METHYLMERCURY IN FISH-EXPLORING RELATIVE RISKS TO WILDLIFE AND HUMAN HEALTH

Much of the basis for recent action on mercury in North America stems from the extensive documentation of elevated levels of its most toxicologically-relevant form methylmercury (MeHg) in fish, and the subsequent risks these concentrations pose to human and environmental health. The primary pathway of MeHg exposure in humans is through ingestion of contaminated fish. As a result, there are more fish advisories established for mercury in North America than any other contaminant (2550 advisories Canadian waterbodies alone in 1996). A national database of methylmercury concentrations in fish is being developed, where, to date, 300,000+ data points have been compiled from all regions of Canada. A GIS-based analysis exploring this spatial and temporal variation has been recently initiated using national tissue residue guidelines as reference values to help investigate and communicate the relative risks to wildlife and human health. In addition, this analysis will aid in addressing the relative contributions from human activities vs. natural processes, the benefits to Canadian ecosystems from controls to date and the extent to which the current science can predict the benefits from further control actions.

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[4] DAMSA, Thunder Bay, ON

PO-69

PLANTE[1] P., Y. COSSETTE[2] , D. MORIN[1], J. PINEAULT[3], C. ROY[4]

FUTURE USINE DE PYROCHEM-SAGUENAY, JONQUIÈRE - PRINCIPES DIRECTEURS POUR L'ÉLABORATION D'UN SYSTÈME DE MANAGEMENT ENVIRONNEMENTAL

L'usine de Pyrochem-Saguenay à Jonquière, qui doit débuter ses opérations à la fin de 1999, transformera des écorces en huiles et en charbon de bois. Ce sera la première plateforme industrielle de la technologie du Pyrocyclage[MC], un procédé de pyrolyse sous vide commercialisé par le Groupe Pyrovac, en association avec les sociétés Rexfor, Sodexfor, l'Université Laval, et la firme néerlandaise UNA par sa filiale Ecosun, spécialisée dans les technologies de dépollution en Europe. Le Pyrocyclage[MC] permet de transformer des matières résiduelles organiques en produits à valeur ajoutée par voie de décomposition thermique, et d'extraire les composés organiques contenus dans des matières et sols contaminés.

Pyrochem-Saguenay transformera annuellement 160 000 tonnes d'écorces de bois résineux provenant de l'exploitation forestière en une production de 23 000 tonnes d'huile de bois et 25 000 tonnes de charbon de bois. Les écorces représentent un sous-produit de l'industrie forestière qui n'est pas pleinement exploité. Au Québec, 2.2 millions de tonnes sont produites annuellement, dont environ les deux tiers trouvent une application, principalement dans le domaine de l'agriculture et le secteur des pâtes et papiers. L'accumulation des écorces dans les sites d'entassement et d'enfouissement, en plus de ne pas être valorisées à des fins énergétiques ou autres, pose de sérieux problèmes pour l'environnement, dû aux eaux de lixiviation qui en résultent. Ces eaux renferment d'importantes quantités de composés phénoliques et d'acides résiniques gras, et la demande biochimique en oxygène (DBO) est très élevée, ce qui constitue ainsi un danger potentiel pour la vie aquatique.

Nous exposerons dans cette présentation les principes directeurs qui ont fait l'objet de considérations dans l'élaboration d'un système de management environnemental (SME) pour la future usine de Pyrochem-Saguenay, en vue d'une intégration au système de gestion global de l'entreprise. Une description sommaire de l'usine est faite, ainsi que de l'organisation du personnel qui comprendra une trentaine d'employés. Les avantages découlant de la mise en place d'un SME pour Pyrochem-Saguenay sont discutés. Le système de SME proposé est inspiré du système ISO 14001. Nous abordons plus en détail dans cette présentation, la définition de la politique environnementale et l'élaboration de la planification du SME proposé, alors que la mise en œuvre, l'évaluation du système et sa revue périodique en vue d'une amélioration continue sont discutés sommairement.

[1] PyroSystèmes Inc.
[2] Ressources-Action Inc.
[3] Groupe conseil TS Inc.
[4] Institut Pyrovac Inc.

PO-70

NIIMI[1] A.J.

FACTORS THAT CAN INFLUENCE THE DECISION TO USE CHEMICALS TO TREAT BALLAST WATER FOR AQUATIC NUISANCE SPECIES

The accidental transport of nonindigenous organisms to distant aquatic ecosystems continues to be a global issue. This concern is particularly relevant in the Laurentian Great Lakes where major ecological and economic impacts have occurred within the past decade. Exotic fish species including the ruffe and round goby, and nonfish species like zebra mussel and spiny water flea, have assumed dominant status in some water bodies. The presence of other nonindigenous species in the Great Lakes have been confirmed although their current or potential impact is largely unknown. Various groups working on control measures have suggested ballast water carried by oversea vessels entering the Great Lakes is an important mode for accidental introduction, and its treatment would be an effective preventative measure. Chemical treatment is one option, but a number of factors must be assessed before its use can be seriously considered. These factors includes the efficacy of the chemical on the target organisms, its impact on the surrounding environment, and legal and moral issues on its application. Some studies have examined the use of hydrogen peroxide, several organic acids and glutaraldehyde as possible chemicals for use in this application. Issues relating to the use of these and other chemicals will be discussed.

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PO-71

ALLAN[1] R., P.G.C. CAMPBELL[2], B. CONARD[3]., G.C. EDWARDS[4], B. HALE[4], A. HOFFER[5] , R. GARRETT[6], R. PIERCE[7], R. PRAIRIE[8] , K. PUCKETT[9] L. RITTER[4]

METALS IN THE ENVIRONMENT (MITE): A RESEARCH PROGRAM

The future use of metals in the world's economy is currently the subject of some considerable debate, particularly within the European Economic Community. The Canadian Network of Toxicology Centres (CNTC) in collaboration with the Mining Association of Canada (MAC), Ontario Hydro, Natural Resources Canada, Environment Canada and Department of Fisheries and Oceans, has established a research network to improve the estimates of long term risk to ecosystems from metals associated with mining, metallurgy, manufacturing and energy production. The network is organized around three themes: [1] natural and anthropogenic sources of metals; [2] transport and transformation of metals; and [3] fate and impacts of metals. These three themes are inextricably linked. For example, metals introduced into the earth's surface environment, whether as the result of natural or anthropogenic processes, are subjected to various transformation and transport processes. For any given metal, the nature and dynamics of these processes will be affected by the metal's speciation; reciprocally, however, these processes may well alter a metal's speciation and thus affect its fate and its impact on the biotic components of the ecosystem. The overall need is to determine the relative contributions of natural and anthropogenic sources to metal loadings to the various environmental "spheres" (atmosphere, geosphere, hydrosphere and biosphere) over time and space, and to evaluate the exposure of receptor organisms, as well as the ecological impacts of these metal loadings. Support for the network is provided by NRCanada, EnvCanada, DFO, MAC and Ontario Hydro; each of these constituencies is represented on the Steering Committee (the authors of this paper), the responsibility of which is to guide the activites of the network. The research network places a high priority on collaborations, both among disciplines and between university and government scientists; this will ensure optimal progress towards the goals of the network.

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[7] DFO
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[9] AES EnvCan

PO-72

DÉSY[1] J.C., B. PINEL-ALLOUL[1], P.G.C. CAMPBELL[2]

BIOACCUMULATION OF TRACE METALS IN ST. LAWRENCE BENTHIC INVERTEBRATES : THE AMPHIPOD *GAMMARUS FASCIATUS* MODEL

We evaluated the potential use of the amphipod *Gammarus fasciatus* as bioindicator of metal pollution in the St. Lawrence River, and developed empirical models predicting metal concentrations in amphipods from those in sediments and aquatic plants. Amphipods were collected in 20 littoral stations located in the fluvial lakes (Lakes St. François, St. Louis and St. Pierre) and the freshwater corridors (Laprairie Basin, Contrecoeur Islands) of the St. Lawrence River. Amphipods were analysed for Cd, Ni, Pb, Cu and Zn, and metal concentrations in the amphipods were related with those in macrophytes and filamentous algae, and in nearby sediments. We also attempted to validate previous models developed for the same species by Amyot *et al.* (1994) by relating predicted metal concentrations based on previous models to those observed in this study. Cd in amphipods was related positively to Cd free ions concentrations at the water/sediment interface, and negatively to water pH, and Ca concentrations, and amphipod size, as already observed by Amyot (1994). In contrast, previous model developed for Ni, Pb.,Cu and Zn did not fit our observed values. New models were developed for those metals, including as explaining factors 1) metal concentration in plants and filamentous algae, 2) metal concentrations at the water/sediment interface, 3) ligands in sediments (Fe and Mn oxyhydroxides, organic carbon), 4) water characteristics (pH, Ca, COD), and amphipod size. The models explained between 57 and 83% of total variance in metal concentrations in the amphipod *Gammarus fasciatus*, which appeared as a promising tools to biomonitor metal pollution in the St. Lawrence River.

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PO-73

CROTEAU[1] M.N., L. HARE[1]

INFLUENCE OF FOOD RELATED VARIABLES ON CD ACCUMULATION BY THE BIOMONITOR *CHAOBORUS*

Cadmium concentrations in a laked-welling insect (*Chaoborus*) can be related to those in their habitat with the free-ion activity model, provided that competition between hydrogen and cadmium ions for biological uptake sites is taken into account. The strong relationship observed between Cd concentrations in *Chaoborus* larvae and free Cd ion concentrations does not necessarily mean that the larvae take up their Cd directly from water. Recent information indicates that Cd accumulated by the predator comes almost entirely from its prey. We tested the hypothesis that Cd concentrations in *Chaoborus* are directly related to those in its planktonic prey by measuring Cd concentrations in the predator and in prey collected from a large number of lakes. We show that Cd concentrations in *Chaoborus* larvae are not accurately predicted by Cd concentrations in bulk zooplankton samples. A better relationship was obtained when potential prey were separated according to type, that is, cladocerans or copepods. Our results suggest that biological variables such as prey type, ingestion rate and Cd assimilation efficiency influence Cd concentrations in the predator *Chaoborus*.

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PO-74

ROY[1] I., L. HARE[1]

PREY ARE AN IMPORTANT CADMIUM SOURCE FOR THE BIOMONITOR *SIALIS*

The alderfly *Sialis* (Megaloptera) is a promising biomonitor candidate because of its wide distribution in fresh waters, its large size and its ease of maintenance in the laboratory. Using this insect as a contaminant biomonitor depends on establishing a direct relationship between its contaminant content and the concentration of the contaminant in its surroundings. An important step towards this end is to determine from which environmental compartment the animal obtains a given contaminant, that is, from water or from its food. We exposed *Sialis velata* larvae in the laboratory for 4 days to 3 cadmium (Cd) concentrations in either water or chironomid prey. We ensured that Cd concentrations in both water and prey remained stable throughout the experiment and that the predator was not starved. Prey Cd concentrations were directly related to those in water and food, indicating that the animal takes up Cd from both of these sources. However, food would likely have been the major Cd source if our experiment had been extended over a longer time period. Our results suggest that exposure of *Sialis* larvae to Cd in water alone would likely underestimate the accumulation and toxicity of this metal to the insect. Furthermore, considering prey community composition in a biomonitor model for this insect would likely improve model predictions.

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PO-75

BERRYMAN[1] D.

HEXANE FILLED SEMIPERMEABLE MEMBRANE DEVICES (SPMDs) AND AQUATIC MOSSES FOR THE ROUTINE SURVEILLANCE OF METALS AND ORGANIC TOXICS IN QUEBEC RIVERS

SPMDs and aquatic mosses have now been in use over a period of eight years as biomonitors of metals and toxics in Québec rivers. Aquatic mosses are used for metals, PCBs, organochlorinated pesticides, dioxins and furanes. Mosses are very robust and can withstand severe environmental conditions. Replicates of bagged mosses are placed in rivers during a month, thus providing a time integrated measurement of ambient contamination. SPMDs are used for HAPs, phthalates and other semivolatil organics as well as fatty and resin acids. Most experiments with SPMDs in the U.S.A. are made with polyethylene tubing containing triolein. We use hexane filled cellulose tubing. This spares the time consuming extraction stage of the analysis procedure.

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PO-76

BIRKHOLZ[1] D.A., D. JOHNSTON[1] , A. BOLLOKAMARA[1]

PAH-METABOLITES IDENTIFIED IN THE BILE OF FISH (LONGNOSE SUCKER AND RAINBOW TROUT) COLLECTED DOWNSTREAM OF A CONDENSATE SPILL

Following a spill of condensate into the aquatic receiving environment samples of fish bile were collected from longnose sucker (*Catostomus catostomus*) and rainbow trout (*Oncorhynchus mykiss*) upstream and downstream of the spill site. Bile samples were composited for each species and enzymatically hydrolyzed, extracted, acetylated, silylated and analyzed using gas chromatography/mass spectrometry. Acetylation prior to GC/MS analysis generated unique mass spectra which allowed us to distinguish alcohol and phenol metabolites from one another. Silylation prior to GC/MS analysis does not allow one to distinguish phenol from alcohol metabolites. The major metabolites found to be present in the bile of fish collected downstream of the spill site included alcohol and phenol Phase I metabolites associated with exposure to C_2 - C_4 substituted naphthalene, phenanthrene, fluorene and dibenzothiophene. These compounds were found to be present in the spilled condensate. The highest concentration of metabolites found in the bile of exposed fish were observed to be alcohols associated with exposure to C_2substituted dibenzothiophene and fluorene. It is suggested that these metabolites be monitored to determine whether cleanup efforts are sufficient to reduce future exposure. Bile analyzed from fish taken upstream of the spill site did not contain any of the metabolites found in the exposed fish. This information was collected to determine the potential impact of the spill on the aquatic receiving environment

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PAH EXPOSURE LEVELS IN MUDPUPPY (AMPHIBIAN)

Polycyclic aromatic hydrocarbons (PAHs) are major constituents of petroleum products and are also formed during incomplete combustion of organic matter. The presence of PAHs in the environment is of great concern because of the mutagenic, teratogenic and carcinogenic properties of the metabolites produced in exposed organisms. In aquatic systems, PAHs become rapidly associated with particles in the water and are deposited and concentrated in the sediments. In recent years, exposure of fish to PAHs was demonstrated by the detection of pyrenetype metabolites in bile using synchronous fluorescence spectrometry (SFS). The SFS technique, though rather simple, offers a rapid screening tool to estimate recent exposure to PAHs. In the present study, the SFS technique was applied to mudpuppy *(Necturus maculosus),* a large salamander inhabiting lakes and rivers of Northeastern America. The mudpuppy is a benthic carnivorous organism susceptible to the chronic effects of contaminants accumulated through its diet and through contact with the polluted sediments. The study reports concentrations of 1 hydroxy pyrene in bile of several populations of mudpuppy sampled during the winter of 1995 at various sites along three hydrographic systems. The sampling areas include Akwesasne and Batiscan River in the St-Lawrence River system; Des Prairies River and Quesnel Bay both located along the Ottawa River system; Wolfe Island, Long Point and Detroit River in the Great Lakes basin. Des Prairies River and Detroit River were the two sites showing significant differences in concentrations of biliary 1-hydroxy pyrene when compared to all the other sites. However, the mudpuppies collected in Detroit River had, by far, the highest concentrations of biliary 1-hydroxy pyrene (median 798 ng/ml). The biliary 1-hydroxy pyrene concentrations found in the other populations of mudpuppies, with the exception of Des Prairies River (median 84 ng/ml), were often not detected or very close to the detection limit (30 ng/ml). Other studies are underway to evaluate the biological impact of PAHs in mudpuppy and the potential of this amphibian as a sentinel wildlife species for ecotoxicological assessment of the aquatic environment.

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EVALUATING BROMINATED DIPHENYL ETHER DISTRIBUTION WITHIN LAKE TROUT USING HIGH RESOLUTION MASS SPECTROMETRY

Brominated diphenyl ethers (BDPE) are lipophilic compounds with fireretardant properties that are added to manufactured products including paints, plastics and textiles. Although BDPE production is increasing annually, information on the environmental fate of these compounds remains limited. To determine BDPE distribution within aquatic ecosystems, a "dioxin" based analytical method was developed. Twenty-four commercially available BDPE congeners (mono-hepta) were identified using high resolution mass spectrometry (GC-HRMS) ($m/\Delta m = 10\ 000$). Fish homogenates were prepared by a multiple extraction process using sodium sulphate and methylene chloride, gel permeation chromatography and fractionation by silica gel and alumina columns. Samples were concentrated by rotary and nitrogen evaporation. Internal standards consisting of $^{13}C_{12}$tetra-octa chlorinated diphenyl ethers were used to verify the efficacy of the method between samples.

To determine BDPE presence in biota, lake trout (*Salvelinus namaycush*), a top-predator salmonid species with a high lipid content and long life span, were collected from Lake Ontario ($n = 6$), Lake Huron ($n = 6$) and Lake Superior ($n = 6$). Similar BDPE homologue patterns were observed in whole fish homogenates selected from each of the three Great Lakes. Preliminary data from Lake Ontario samples demonstrated elevated levels of all BDPE homologues in comparison to samples from the other two lakes.

The ability to routinely detect BDPE homologues in lake trout indicates that the described GC-HRMS method is reliable and sensitive for determining BDPE concentrations in biological tissues and suggests BDPE may bioaccumulate within aquatic ecosystems.

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PRIX POUR LES MEILLEURS EXPOSÉS PAR DES ÉTUDIANTS/ BEST STUDENT PAPER AWARDS

MEILLEURE PRÉSENTATION ORALE/BEST PLATFORM PRESENTATION

Claude Fortin
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MEILLEURE PRÉSENTATION PAR AFFICHE//BEST POSTER PRESENTATION

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Kusui, Takashi	Toyama Prefectural University	5180	Kosugi-Machi	Toyama	JAPAN	939-0398
Laberge, Denise	UQTR, Dépt. chimie-biologie	C.P. 500	Trois-Rivières	QC	CAN	G9A 5H7
Labrie, Jacques	Alcan International Ltd	1955, Mellon Blvd, P.O. Box 1250	Jonquière	QC	CAN	G7S 4K8
Laflamme, Jean-Sébastien	Université du Québec à Montréal	Sci. Bilologie, CP 8888, Suc. C-V.	Montréal	QC	CAN	H3P 3P8
Lafortune, Anne-Marie	Cent. d'expertise en analyse environ.	360, rue Franquet, Bureau 40	Sainte-Foy	QC	CAN	G1P 4N3
Lalonde, Janick	INRS-EAU, Université du Québec	2800, rue Einstein, CP 7500	Sainte-Foy	QC	CAN	G1V 4C7
Lamberts, Luc	Université de Namur	61, rue de Bruxelles	Bruxelles		BELGIUM	B-5000
Langlois, Claude	Environnement Canada	105 rue McGill	Montréal	QC	CAN	H2Y 2E7
Larouche, Lucien	Métaux Reynolds Ltée	100, route Maritime	Baie-Comeau	QC	CAN	G4Z 2L6
Latreille, Alain	Environnement Canada	105 McGill	Montréal	QC	CAN	H2Y 2E7
Lavergne, Yves	Public Works & Govern. Serv. Can.	901 Cap Diamant	Québec	QC	CAN	G1K 4K1
Lebeuf, Michel	Pêches et Océans	850, route de la Mer	Mont-Joli	QC	CAN	G5H 3Z4
Leblond, Vincent	Université du Québec à Montréal	Sci. Bilologie, CP 8888, Suc. C-V.	Montréal	QC	CAN	H3P 3P8
Leclerc, Jacinthe	Environnement Canada	C.P. 10100	Sainte-Foy	QC	CAN	G1V 4H5
Lee, Kenneth	Fisheries and Oceans Canada	Institut Maurice Lamontagne	Mont-Joli	QC	CAN	G5H 3Z4
Légaré, Benoît	Gouv. du Canada	850, route de la Mer, C.P. 1000	Mont-Joli	QC	CAN	G5H 3Z4
Lemire, Réjean	Centre d'expertise en analyse environ.	2700, rue Einstein, E-RC-200	Sainte-Foy	QC	CAN	G1P 3W8
Lévesque, Aude	UQAM	4413 a, rue Garnier	Montréal	QC	CAN	H2J 3S3
Liber, Karsten	University of Saskatchewan	Toxicology Centre	Saskatoon	SK	CAN	S7N 5R3
Lindeman, Dorothy	Environment Canada	115 Perimeter Road	Saskatoon	SK	CAN	S7N 0X4
Longpré, Guy	CEAEQ	2700, rue Einstein	Sainte-Foy	QC	CAN	G1P 3W2
Lopez, Bobby	Web Spinners Canada Inc	2 Redwater Drive	Toronto	ON	CAN	M9W 1Z6
Loranger, Sylvain	QSAR Inc.	360, rue Saint-Jacques Ouest	Montréal	QC	CAN	H2Y 1P5
Lowell, Richard	National Water Research Institute	11 Innovation Blvd.	Saskatoon	SK	CAN	S7N 3H5
Luross, Jennifer	Dept. of Fisheries & Oceans	Canada Centre for Inland Waters	Burlington	ON	CAN	L7R 4A6

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MacDonald, Gord	Diavik Diamonds Mines Inc.	Suite 2300, 639-5th Ave S.W.	Calgary	AB	CAN	T2P 0M9
MacGregor, Don	Environment Canada	3439 River Road South	Gloucester	ON	CAN	K1A 0H3
Mah-Paulson, May	O'Connor Associates Environ. Inc.	1000, 639 - 5th Avenue SW	Calgary	AB	CAN	T2P 0M9
Mailhiot, Karen	Environnement Canada	Place Vincent Massey	Hull	QC	CAN	K1A 0H3
Manuel, Michelle	BRI-NRC	6100 Royalmount	Montréal	QC	CAN	H4P 2R2
Marshall, Lisa	Cantox Environmental	5475 Spring Garden Road	Halifax	NS	CAN	B3J 3T2
Martel, Louis	Cent.'expertise en analyse environ.	360 rue Franquet, Bureau 40	Sainte-Foy	QC	CAN	G1P 4N3
Martin, Réjean	Université du Québec (UQAR)	300, allée des Ursulines	Rimouski	QC	CAN	G5L 3A1
Marwood, Chris	Centre for Toxicology	Univ. of Guelph, Bovey Bldg.	Guelph	ON	CAN	N1G 2W1
Massicotte, Richard	UQAM - Toxen	1200, rue Saint-Alexandre	Montréal	QC	CAN	H3C 3P8
Masters, Wendy	Aquatic Sciences Inc.	PO Box 2205, 250 Martindale Rd.	St. Catharines	ON	CAN	L2R 7R8
Mathieu, Anne	Department of Fisheries & Oceans	Science Branch, P.O. Box 5667	St. John's	NF	CAN	A1C 5X1
McConkey, Brendan	University of Waterloo	Department of Biology	Waterloo	ON	CAN	N2L 3G1
McKee, Paul	Beak International Incorporated	14 Abacus Road	Brampton	ON	CAN	L6T 5B7
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McMaster, Mark	Environment Canada, NWRI	Canada Centre for Inland Waters	Burlington	ON	CAN	L7R 4A6
Mercier, Louise	Interprète					
Mercier, Vincent	Nadec experts-conseils inc.	378, rue Jean-Talon	Vanier	ON	CAN	K1L 6T9
Metcalfe, Chris	Trent University	Environ.l & Resource Stud. Prog.	Peterborough	ON	CAN	K9J 7B8
Miasek, Peter	Imperial Oil	90 Wyndord Dr.	North York	ON	CAN	M3C 1K3
Micha, Jean-Claude	URBO, FUNDP	61, rue de Bruxelles	Namur		BELGIUM	B-5000
Michon, Pierre	Environnement et Faune Québec	675, boul. René-Lévesque Est	Québec	QC	CAN	G1R 5V7
Middelraad, Irene C. J.	ESG International Inc.	361 Southgate Drive	Guelph	ON	CAN	N1G 3M5
Mikaelian, Igor	Can. Coop. Wildlife Health Centre	Univ. de Montréal, 3200 Sicotte	Saint-Hyacinthe	QC	CAN	J2S 7C6
Milani, Danielle	Environment Canada	867 Lakeshore Rd.	Burlington	ON	CAN	L7R 4A6
Miller, Jennifer	Miller Environmental Sciences Inc.	1839 Lockhart Road	Stroud	ON	CAN	L0L 2M0
Mondal, Sabyasachi	University of Gent	J plateaustraat 22,	Gent		BELGIUM	9000
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Nimmo, Angela	Dalhousie University	Dept. of Oceanography	Halifax	NS	CAN	B3H 4J1
Nipper, Marion	Texas A&M University-Corpus Christi	6300 Ocean Drive, Suite 3200	Corpus Christi	TX	USA	78412
Norwood, Warren	Environment Canada, NWRI	Canada Centre for Inland Waters	Burlington	ON	CAN	L7R 4A6
Oakes, Ken	University Of Guelph	Department of Zoology	Guelph	ON	CAN	N1G 2W1
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Ouellet, Sylvain	Environment Canada	Place Vincent Massey	Hull	QC	CAN	K1A 0H3

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Pauwels, Stan	ABT Associates Inc.	55 Wheeler Street	Cambridge	MA	USA	02138-1168
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Perceval, Olivier	Univ. de Montréal, Dept. sci. biol.	C.P. 6128, succ. Centre-ville	Montréal	QC	CAN	H3C 3J7
Peters, Lisa	University of Waterloo	Dept of Biology	Waterloo	ON	CAN	N2L 3G1
Pickard, Janet	B.C. Research Inc.	3650 Wesbrook Mall	Vancouver	BC	CAN	V6S 2L2
Pilon, Adrien	Conseil national de la recherche	6100 Royalmount	Montréal	QC	CAN	H4P 2R2
Pinel-Alloul, Bernadette	GRIL, Univ. Montréal	C.P. 6128. Succ. Centre ville	Montréal	QC	CAN	H3C 3J7
Piuze, Jean	Pêches et Océans	850, route de la Mer, C.P. 1000	Mont-Joli	QC	CAN	G5H 3Z4
Plante, Pierre	Pyro-Systèmes inc.	333, rue Franquet	Sainte-Foy	QC	CAN	G1P 4C7
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Portt, Cam	C. Portt and Associates	56 Waterloo Ave.	Guelph	ON	CAN	N1H 3H5
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Prairie, Robert	Noranda	240, boul. Hymus	Pointe-Claire	QC	CAN	H9R 1G5
Provencher, Marc	Environnement Canada	105, rue McGill	Montréal	QC	CAN	H2Y 2E7
Prud'homme, Anne-Marie	TransÉnergie	800, boul. de Maisonneuve Est	Montréal	QC	CAN	H2L 4M8
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Renoux, Agnès	National Research Council Canada	6100 Royalmount Avenue	Montréal	QC	CAN	H4P 2R2
Ribey, Sandra	Environment Canada, EEM Office	Place Vincent Massey	Hull	QC	CAN	K1A 0H3
Richard, Francine	Ministère Environ. et Faune Québec	675, boul René-Lévesque E	Québec	QC	CAN	G1R 5V7
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Roberge, Jacques G.	Daishowa inc	C. P. 1487, 10 blvd.des Capucins	Québec	QC	CAN	G1K 7H9
Roberge, Linda	Univ. Québec à Rimouski. Oceanogr.	310, allée des Ursulines	Rimouski	QC	CAN	G5L 3A1
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Rochfort, Quintin	Environment Canada, NWRI	Canada Centre for Inland Waters	Burlington	ON	CAN	L7R 4A6
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Ruby, Sylvia	Concordia University, Biologie	1455, boul. de Maisonneuve O	Montréal	QC	CAN	H3G 1M8
Russo, Nick	Environment Canada	224 West Esplanade	North Vancouver	BC	CAN	V7M 3H7
Rutherford, Les	Environment Canada, EPB	Queen Square, 45 Alderney Dr.	Dartmouth	NS	CAN	B2Y 2N6
Salahub, Robert (Bob)	Norwest Labs	9938-67 Avenue	Edmonton	AB	CAN	T6E 0P5
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Salazar, Sandra	EVS Consultants	200 W. Mercer St.-S403	Seattle	WA	USA	98034
Schetagne, Roger	Hydro-Québec	855, rue Sainte-Catherine Est	Montréal	QC	CAN	H2L 4P5
Schneider, Uwe	Environment Canada	Place Vincent Massey.	Hull	QC	CAN	K1A 0H3
Schneider, Tracy	Environment Canada	Place Vincent Massey	Hull	QC	CAN	K1A 0H3
Schroeder, Julie	Beak International Inc.	14 Abacus Rd.	Brampton	ON	CAN	L6T 5B7
Schryer, Richard	Golder Associates Ltd.	209-2121 Airport Drive	Saskatoon	SK	CAN	S7L 6W5
Scott, Jennifer D.	HydroQual Labs Ltd.	3 - 6125 12th Street	Calgary	AB	CAN	T2H 2K1
Scott, Ian	Environment Canada	867 Lakeshore Rd.	Burlington	ON	CAN	L7R 4A6
Scroggins, Richard	Environment Canada, ETC	3439 River Head South	Gloucester	ON	CAN	K1A 0H3
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Sherry, Jim	Environment Canada	867 Lakeshore Rd.	Burlington	ON	CAN	L7R 4A6
Silverwood, Alain	Maxxam Analytics Inc.	9420, Côte de Liesse	Lachine	QC	CAN	H8T 1A1
Simmons-Ferguson, H.	Environment Canada	Place Vincent Massey	Hull	QC	CAN	K1A 0H3
Simon, Kenneth	Enviro Systems	PO Box 778	Hampton	NH	USA	03842
Snow, Stephen	Dept. Fisheries and Oceans	NW Alt Fisheries Centre	St. John's	NF	CAN	A1C 5X1
Spry, D.J.	Ontario Ministry of the Environment	135 St. Clair Ave. W.	Toronto	ON	CAN	M4V 1P5
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Steele, Tracey	York University	P.O. Box 536	Virgil	ON	CAN	L0S 1T0
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Stefanik, Melanie	Beak International inc.	14 Abacus Rd.	Brampton	ON	CAN	L6T 5B7
St-Laurent, Donald	Environnement Canada	105, McGill	Montréal	QC	CAN	H2Y 2E7
St-Louis, Richard	Université du Québec à Rimouski	300, allée des Ursulines	Rimouski	QC	CAN	G5L 3A1
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Sunahara, Geoffrey	National Research Council Canada	6100 Royalmount Avenue	Montréal	QC	CAN	H4P 2R2
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Tae, Maret	Knight Piesold	34 Commerce Cres.. P.O. Box 10	North Bay	ON	CAN	P1B 8G8
Talbot, Cécile		4193, D'Estrées	Québec,	QC	CAN	G2A 3R4
Taylor, Barry	Taylor Mazier Associates	R. R. # 3,	St. Andrews	NS	CAN	B0H 1X0
Taylor, Kenneth	Environment Canada	Place Vincent Massey	Hull	QC	CAN	K1A 0H3
Taylor, Darrell	N. S. Dept. of the Environment	P.O Box 2107	Halifax	NS	CAN	B3J 3B7
Tessier, Louis	Univ. du Québec à Trois-Rivières	Dép. Chimie-Biologie, C.P. 500	Trois-Rivières	QC	CAN	G9A 5H7
Tessier, André	INRS-Eau	2700, rue Einstein, C.P. 7500	Sainte-Foy	QC	CAN	G1V 4C7
Tétreault, Gérald	CCIW	35 Paisley	Guelph	ON	CAN	N1H 2N5
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Thellen, Micheline	Ministère Santé et Services sociaux	4772, rue Gaboury	Saint-Augustin	QC	CAN	G3A 1E9

Thibault, Ian	PPG Canada Inc.	C.P. 2010	Beauharnois	QC	CAN	J6N 3C3
Thibault, Germain	Environnement ESA inc.	207, rue Belvédère Nord	Sherbrooke	QC	CAN	J1H 4A7
Thomas, Gregory P.	G3 Consulting Ltd.	1A - 12880 Bathgate Way	Richmond	BC	CAN	V6V 1Z4
Thybaud, Éric	INERIS, Parc technol.	ALATA, Boite post. 2	Verneuil-en-Halatte		FRANCE	F-60550
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Tremblay, Alain	Hydro-Québec	855, rue Sainte-Catherine	Montréal	QC	CAN	H2L 4P5
Tremblay, Andrée		856, rue Pontbriand	Sainte-Foy	QC	CAN	G1V 3G4
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Van Coillie, Germaine	ATW	2692, rue D'Aurigny	Sainte-Foy	QC	CAN	G1V 1B5
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Wells, Peter	Environment Canada	Queen Square,. 45 Alderney Dr.	Dartmouth	NS	CAN	B2Y 2N6
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Zajdlik, Barry	B. Zajdlik & Associates	RR #3	Rockwood	ON	CAN	N0B 2K0
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COMPTES RENDUS DES COLLOQUES/WORKSHOP PROCEEDINGS

The Proceedings of each Annual Aquatic Toxicity Workshop have been published in a series of Technical Reports listed below. These proceedings are generally provided to each Workshop participant, and are also sent to selected libraries, government departments and other agencies. Copies of 4th and subsequent Proceedings are available for a charge, as photocopies or fiche, from Micromedia Limited, 240 Catherine Street, Suite 305, Ottawa, On, K2P 2G8 (613-237-4250).

Proceedings of the 24th Annual Aquatic Toxicity Workshop : October 19-22, 1997, Niagara Falls, Ontario. Edited by A.J. Niimi, G.L. Parrott and D.G. Spry. Can. Rep. Fish Aquat. Sci. 2192 : 135 p.

Proceedings of the 23rd Annual Aquatic Toxicity Workshop : October 7-9, 1996, Calgary, Alberta. Edited by J.S. Goudey, S.M. Swanson, M.D. Treissman and A.J. Niimi. Can. Tech. Rep. Fish. Aquat. Sci. 2111 : 196 p.

Proceedings of the 22nd Annual Aquatic Toxicity Workshop : October 2-4, 995, St-Andrews, New Brunswick. Edited by K. Haya and A.J. Niimi. Can. Tech. Rep. Fish. Aquat. Sci. 2093 : 159 p.

Proceedings of the 21st Annual Aquatic Toxicity Workshop : October 3-5, 1994, Sarnia, Ontario. Edited by G.F. Westlake, J.L. Parrott and A.J. Niimi. Can. Tech. Rep. Fish. Aquat. Sci. 2050 : 179 p.

Proceedings of the 20th Annual Aquatic Toxicity Workshop : October 17-21, 1993, Quebec City, Quebec. Edited by R. Van Coillie, Y. Roy, Y. Bois, P.G.C. Campbell, P. Lundahl, L. Martel, M. Michaud, P. Riebel and C. Thellen. Can. Tech. Rep. Fish. Aquat. Sci. 1989 : 331 p.

Proceedings of the 19th Annual Aquatic Toxicity Workshop : October 4-7, 1992, Edmonton, Alberta. Edited by E.G. Baddaloo, S. Ramamoorthy and J.W. Moore. Can. Tech. Rep. Fish. Aquat. Sci. 1942 : 489 p.

Proceedings of the 18th Annual Aquatic Toxicity Workshop : September 30- October 3, 1991, Ottawa, Ontario. Edited by A.J. Niimi and M.C. Taylor. Can Tech. Rep. Fish. Aquat. Sci. 1863 : 381 p.

Proceedings of the 17th Annual Aquatic Toxicity Workshop : November 5-7, 1990, Vancouver, British Columbia. Edited by P. Chapman, F. Bishay, E. Power, K. Hall, L. Harding, D. McLeay, M. Nassichuck and W. Knapp. Can. Tech. Rep. Fish. Aquat. Sci. 1774 : 1213 p.

Program of the 16th Annual Aquatic Toxicity Workshop : November 6-9, 1989, Winnipeg, Manitoba. Edited by S.L. Leonhart, Freshwater Institute, Fisheries Oceans, Winnipeg : 16 p.

Proceedings of the 15th Annual Aquatic Toxicity Workshop : November 28-30, 1988, Montreal, Quebec. Edited by R. Van Coillie, A.J. Niimi, A. Champoux and G. Joubert. Can. Tech. Rep. Fish. Aquat. Sci. 1714 : 244 p.

Proceedings of the 14th Annual Aquatic Toxicity Workshop : November 2-4, 1987, Toronto, Ontario. Edited by A.J. Niimi and K.R. Solomon. Can. Tech. Rep. Fish. Aquat. Sci. 1607 : 201 p.

Proceedings of the 13th Annual Aquatic Toxicity Workshop : November 12-14, 1986, Moncton, New Brunswick. Edited by J.S.S. Lakshminarayana. Can. Tech. Rep. Fish. Aquat. Sci. 1575 : 178 p.

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